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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIII.—No. 2940.] *LONDON: FRIDAY, MAY 5, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

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BOILER FEED PUMPS.
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PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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Agents: MARINE WORKS, Ltd., Friars House, 39-41, New Broad St., LONDON, E.C.2.
See half-page Advert. last week and next week. 675

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Thos. Piggott & Co., Limited,
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"Spencer-Hopwood" Patent
WATER TUBE **Boilers.** *See page 98.* 577
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Specification and Workmanship equal to Main Line Locomotives.
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Boilers.
See page 17. 9947

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Sizes 1½ B.HP. and upwards.
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See advertisement alternate weeks. 9335

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S. H. HENWOOD & CO., LTD.,
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See Advertisement page 70, April 28.

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designed and constructed by
MANNING, WARDLE AND COMPANY, Limited,
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See their Illus. Advertisement, page 96, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
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MOTHERWELL. Od 3383

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for
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and
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Electric Transporters.
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John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28, 1921.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 637
Lists of Standard Sizes on Application.
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See Advertisement page 84. 9052

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&c. &c. 9694

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Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
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Yarrow Patent Water-tube Boilers.
9664
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YARROW & CO. (1922), Ltd., Scotstoun, Glasgow.

Matthew Paul & Co., Ltd.
Levenford Works, **Dumbarton.** 9518
See Full Page Advt., page 48, April 28.

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Walter Somers, Limited,
HALESOWEN. 7116

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
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See Full page Advertisement, page 65, April 28.

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Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS
ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of Wheels and Axles, Railway Plant, Forgings, Smith-Work, Iron and Brass Castings.
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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
9737
See half-page Advertisement page 42, April 14.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

British Electric Transformer CO., LTD.

PRUDENT PLANNING FOR GOOD AND BAD TIMES.

The 19th ORDINARY GENERAL MEETING of the Company was held at Winchester House, E.C., on Tuesday, 2nd May, 1922, Mr. A. F. BERRY, the Chairman, presiding.

In moving the adoption of the Report and accounts the Chairman compared the items in the Accounts with those of the previous year, the principal point being the addition of £47,000 to the Freehold Land, Buildings, Plant, Machinery, etc., the bulk of which represented new plant and machinery installed during the past year. The loan on Mortgage and Interest accrued, amounting to £31,851, had disappeared from the Balance Sheet as being paid off in full. Of the available cash £88,536 had been invested and such investments had since been sold, the money realised being re-invested as opportunity afforded so that it could be readily used when required for manufacturing purposes. The general charges on Profit and Loss account were £10,500 more than the previous year, but Gross Profit on trading had increased by £40,000 and Net Profit by over £31,000. Out of the available balance of £97,594 they were able to pay for the fourth year in succession a Dividend of 10 per cent. plus 2½ per cent. bonus and to carry forward £12,708. This was the 19th Annual Meeting and none of the previous years had shown anything so good.

The Chairman continued:—

We have been, and are going, through times of such difficulty of late, that I cannot help feeling that the time may not be distant when the strong confidence of the Shareholders will be needed to help us tide over the one or more years during which it may be impossible to produce the splendid results to which we are by now accustomed and therefore expect.

To-day it would have been pleasant to say nothing but those things that please.

We have, however, at the Annual General Meeting, always endeavoured to give to the Shareholders as much information as we could, and where it has been in anyway possible to forecast results we have endeavoured to do so. You may remember that last year we started with 60 per cent. more work in hand (in money value or 20 per cent. more in horse power) than we had at the beginning of 1920. This year we started with roughly 60 per cent. *less* work in hand (calculated in horse power, it would be still *worse* in money value) than we had at the beginning of 1921. This work in hand will not carry with it the same ratio of profit which we looked forward to at our last year's meeting.

The difficulties due to this shortage of work, magnified as they are by strikes and lock-out troubles, cannot be overlooked.

Last year I ventured the opinion that "The next few years will test the capacity of even the best Captains of Industry." Some of us hoped that adversity would bring the different interests in the ranks of industry rather closer together, but we all know this is a state of affairs to be wished for and worked for rather than one accomplished.

It appears to me that the active minorities whose business or avowed intention it is to make trouble between the different members of the various British Industries' teams are having their own way far too much, and I fear that industry will not prosper as we desire until its natural leaders are actually encouraged to lead. You are well aware that the Stock Exchange, which usually bases its opinions and judgment upon the ideas of those best able to advise it, are indicating in no uncertain way their belief in a return of comparatively good times.

There are signs, too, in the heavier industries of some improvement, but I shall be agreeably surprised if the return of prosperity will be sufficient to enable Ordinary Dividends of any appreciable value to be obtained, at any rate, for the next year.

These extremely bad times through which we are passing can be made to have their uses, and in a Company such as ours there is very much to do in the way of staff work and co-ordination of effort with other sections of the industry. It is only by a continuance and even an improvement on the efforts of office and factory staff that we shall fit ourselves to play our full part in those better times which somewhere ahead we are steering and working for.

Few of the Shareholders outside this Company realise what an effort it has been to achieve the results shown. They are the results of a carefully thought out policy carried out loyally and efficiently in the main by office and works staff, and it is a pleasure once more to be able to thank all those who have pulled their full weight during the past year and enabled us to accomplish what we have done.

Some of you may be Shareholders in concerns which are considered less fortunate than ourselves. I may tell you that unless our plans had been laid long ago with the greatest prudence and carried out with persistent care, we might, even during this past year, have found ourselves with a heavy loss instead of record profits. I do not mention these facts in any boastful spirit, but I wish Shareholders to appreciate the position and times through which we are passing.

Once again it is my pleasure on behalf of the Board to thank not only those of the Company's employees who have done their best in the Company's interests during the past year, but also those Shareholders who do their utmost to make it possible for themselves and their fellow Shareholders, including those who work in office and factory, to derive the greatest advantage from this Company by taking an intelligent interest in its products. On the other hand, it sometimes surprises me how little many of our Shareholders do to further their own general and particular interest in this Company, in spite of my requests made from year to year that they should take an interest in their Company's products if they desire to take the maximum interest out. The real and ascertained value of what is done by the comparatively few gives a very clear indication of what great benefits to themselves and the Company would result from individual interest and action by the many. For instance, Shareholders might well go into Electrical shops of all descriptions and ask about "TRICITY" goods—"'TRICITY' AS ADVERTISED"—"How it can help ME—Where—Why—and to what extent." Such action on your part may appear small to you, but please think of its effect taken with that of thousands of others in and out of this Company.

The Report and Accounts were adopted unanimously.

U 133

1922 B. No. 1475.

IN THE HIGH COURT OF JUSTICE
CHANCERY DIVISION.
MR. JUSTICE SARGANT.

IN THE MATTER OF LETTERS PATENT No. 6102 of 1909, 6751 of 1909, 603 of 1913, all granted to HUGH FRANCIS FULLAGAR
and
IN THE MATTER OF THE PATENTS AND DESIGNS ACT 1907 and 1919.
APPLICATION BY THE BALANCED ENGINE SYNDICATE LIMITED.

Notice is Hereby Given that

The Balanced Engine Syndicate Limited whose registered office is Pilgrim House Newcastle-on-Tyne assignees of the above-named Letters Patent has by Originating Summons dated the 16th day of March 1922 applied that the terms of the said Letters Patent may be extended for five years or for such period as the Court shall think fit.

And NOTICE IS HEREBY GIVEN that on Tuesday the 13th day of June 1922 application will be made to the Court that a day may be fixed before which the said summons shall not be in the paper for hearing.

And NOTICE IS HEREBY GIVEN that any person desirous of being heard in opposition to the said summons shall at least seven days before the said 13th day of June 1922 lodge notice of such opposition at the Chambers of the Judge, Room No. 157, Royal Courts of Justice, Strand, London, and serve a copy thereof upon the applicants.

Dated the 27th day of April, 1922.

FAITHFULL, OWEN & FRASHR,
9 & 10, George Yard,
Lombard Street, E.C. 3.
Agents for
L. H. BOOTH,
Newcastle-on-Tyne,
on whom all documents requiring service may be served. U 127

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by MR. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 58 SOUTH JOHN STREET, LIVERPOOL. 575

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—29, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 566

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 26 years' professional experience. Address, 7434, Offices of ENGINEERING.

TENDERS.

TO ENGINEERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for Dry Docking and

carrying out certain REPAIRS to TRAINING SHIP "EXMOUTH," now lying off Grays, Essex, in accordance with drawing and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Drawing, Specification and Form of Tender may be inspected at the office of the Board, Embankment, E.C. 4, on and after Ten a.m. on 8th May, 1922, and the Drawing, Specification, and Form of Tender can then be obtained upon payment of a deposit of £1 in respect of the work. The amount of the deposit will be returned only after the receipt of a *bona-fide* Tender sent in accordance with the instructions of the Form of Tender and after the Specification and the Drawing have been returned.

Tenders addressed as noted on the form must be delivered at the Office of the Board not later than 2.30 on Monday, 15th May, 1922. U 131

(By order) DUNCOMBE MANN,
Clerk to the Board.

OLDHAM CORPORATION ELECTRICITY DEPARTMENT.

PLANT FOR SALE.

The Corporation of Oldham are prepared to receive:—

Offers for the following

PLANT:—

(1.) One—36,000 lbs. of water per hour Babcock and Wilcox Land Type WATERTUBE BOILER, complete with Babcock and Wilcox Chain Grate Stoker; Greens Economiser: Musgrave Induced Draught Plant.

(2.) One—1200 Kw. Mixed Pressure Brush D.C. Turbo Tandem GENERATOR; Hirrlees Watson High Barometric Jet Condensing Plant.

Further particulars of the above plant may be obtained from the Borough Electrical Engineer, F. L. OGDEN, Greenhill Electricity Offices, Oldham.

Sealed Offers, addressed to The Chairman of the Electricity Committee, must be delivered at the Greenhill Electricity Offices, Oldham, not later than first post Monday, the 15th May, 1922, and endorsed Offer for Plant.

The Corporation do not bind themselves to accept any Offer.

Town Hall, Oldham. 28th April, 1922.
J. J. WILLIAMS, Town Clerk. U 138

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of

STEEL MATERIAL (293 tons), as per specification to be seen at the Company's Offices.

Tenders, addressed to the undersigned, and marked "Tender for Steel Material," are to be lodged not later than Noon on Monday, the 15th day of May, 1922.

For each Specification a fee of 10s. will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.

267, Gresham House,
Old Broad Street,
London, E.C. 2.
26th April, 1922. U 112

SIAM STATE RAILWAYS.

NOTICE.

Tenders are Invited for

SUPPLY of LOCOMOTIVES and TENDERS. Specifications and Drawings may be obtained against payment of £2 from Messrs. C. P. SANDRENO, 40, Grosvenor Gardens, London, S.W. 1.

Sealed Tenders with the inscription "Tender for Supply of Locomotives and Tenders," must be forwarded to the undersigned, at whose office in Bangkok, Siam, they will be received up to Two p.m. on the 15th of September, 1922, at which place and hour the Tenders will be publicly opened and read.

Right is reserved to reject any or all Tenders and to accept any Tender which, in the opinion of the undersigned, is to the best interests of the Siam State Railways.

Department of State Railways,
Bangkok, 6th March, 1922. U 103
General PURACHATRA,
Commissioner-General.

The Corporations of Middles-

BROUGH, THORNABY-ON-TEES and STOCKTON-ON-TEES, having taken over the Undertaking of the Imperial Tramways Company Limited in the three Boroughs, have FOR SALE portions of the LAND, BUILDINGS, MACHINERY, and PLANT which are not required by the Corporations in connection with the running of the Tramway Undertaking subsequent to the transfer.

The particulars are as follows:—

(1.) Buildings utilised by the Imperial Tramway Company for the purpose of generating electricity and consisting of:—

Power house, measuring or containing 235,610 cub. ft.
Boiler house containing 193,031 cub. ft.
Offices containing 21,546 cub. ft.
Smoke Stack of best pressed bricks and lined with fire bricks.
All necessary foundations for the machinery.
A Wharf, 200 ft. long abutting on the River Tees constructed of pitch pine timber and red deal with 236 sq. yds. of slag pitching.
Boundary Walls together with freehold land upon which the buildings are erected and adjacent and incident thereto containing 426 sq. yds. or thereabouts.

The buildings are built of best pressed brick; the Power House being lined with glazed bricks.

The Power Station is equipped with 3 Corliss horizontal, compound condensing engines, direct-coupled to 3 phase, 25 cycle 2500 volt generators, 2 Rotary Converters 25 cycle wound to give 500 to 550 volts on D.C. side, Rotary Converter Booster, Switchboard, Overhead Travelling Crane, Motor-driven Centrifugal Circulating Pump, 3 Babcock and Wilcox Boilers, evaporation 12,000 lbs. with Vickers' Mechanical Stokers, Electric Motor for driving Mechanical Stokers, Green's Economiser, Coal Bunkers, Coal Elevator (fitted with Avery's Automatic Weigher) Electric Grab Crane, Cables, Piping, Electric Lighting equipment and other forms of plant and machinery necessary for a fully equipped Electricity Generating Station.

The whole of the above are situate and adjacent to Bridge Road, Stockton-on-Tees, and abut upon the River Tees a little to the west of the Victoria Bridge which crosses the Tees at or near to that point.

The buildings which were erected about 22 years ago are built in a most substantial manner and are in good order and condition.

The Plant has likewise been kept in first-class running order.

In addition to the above, there is also for sale:—

(2.) Plant and Machinery in the Newport Sub-Station situate in Newport Road in the Borough of Middlesbrough, consisting of:—

3 Rotary Converters, Single-phase Air-cooled Transformers, Centrifugal Fans, Electric Motors, Switchboard, 13 panels, and all necessary cables.

(3.) Also the following plant now at Bridge Road premises, Stockton-on-Tees:—

Weighbridge, Hydraulic Lifting Jack, Axle Tester, Hydraulic Rail Bender, Hydraulic Punching Bar, Wells' Light, Snow Sweeper, Hand Ambulance.

TENDERS ARE INVITED FOR THE PURCHASE OF:—

(1.) The Land, Buildings, Machinery and Plant as described above situate in or near to Bridge Road, Stockton-on-Tees.

(2.) The Plant and Machinery at the Newport Sub-Station.

(3.) The Miscellaneous Plant or alternatively, Tenders, under the head of—1, 2 and/or 3 separately or any two of them.

Particulars and Conditions of Sale and permission to view can be obtained from the undersigned, to either of whom sealed Tenders must be sent no later than May 30th, 1922.

Please mark envelopes "Tenders for Tramway Premises or Plant."

The Corporations give no undertaking to accept either the highest or any other Tender or Tenders that may be sent in.

PEMBTON KITCHEN,
Town Clerk and Clerk to the Tramways Committee, Municipal Buildings, Middlesbrough.
THOS. DOWNEY,
Town Clerk and Clerk to the Stockton and Thornaby Joint Tramways Committee.
Borough Hall, Stockton-on-Tees.
6th April, 1922. T 952

North Eastern Railway.—

The Directors are prepared to receive TENDERS for the RECONSTRUCTION of the ROADWAY over the High Level Bridge, Newcastle. The work consists of about 350 tons of steel-work, 40 tons of cast ironwork, 10,000 c. ft. of timber, and 1800 sq. yds. of wood block paving. Plans may be seen, and Specification, Detailed Quantities, and Form of Tender obtained on personal application at the Office of Mr. C. F. BERKEHEM, Chief Engineer, York, on and after Wednesday, May 3rd, 1922. Sealed Tenders marked "High Level Bridge" must be received by the Secretary, York, not later than Nine a.m. Wednesday, May 17th, 1922. The Directors do not bind themselves to accept the lowest or any Tender.

R. FRANCIS DUNNELL, U144
York, 2nd May, 1922. Secretary.

RUGBY URBAN DISTRICT COUNCIL.

TO ENGINEERS, METAL MERCHANTS, AND OTHERS.

The Water Committee of the above Council invite

Offers for Two Babcock and

Wilcox BOILERS with Fittings, &c., as they stand.

These may be seen at the Avon Water Works, Brownsover Mill Road, Rugby, on any day by appointment, between the hours of Ten a.m. and Five p.m., except Saturdays or Sundays.

Offers, endorsed "Boilers," to be addressed to the undersigned and delivered at his office, not later than Monday Noon, the 29th inst.

JOHN H. SHARP,
Water Engineer.
Benn Buildings, Rugby,
3rd May, 1922. U 164

STEPNEY BOROUGH COUNCIL.

ELECTRICITY SUPPLY.

A—BOILERS AND BOILER-HOUSE ACCESSORIES.
B—TURBO-ALTERNATORS, CONDENSERS, ACCESSORIES AND SWITCHGEAR.

The Electricity Supply Committee of the Stepney Borough Council invite

Tenders from Responsible

Contractors for the CARRYING OUT of the following WORK at the Council's Limehouse Station, viz.:—

(a) The Manufacture, Supply and Erection complete, of Three WATER-TUBE BOILERS, together with Chimneys, Economisers and other accessories.

(b) The Manufacture, Supply and Erection of two 10,000 Kw. TURBO-ALTERNATORS, with Condensers, Accessories and Switchgear.

Copies of the General Conditions, Specifications, Forms of Tender and Drawings, may be obtained from Mr. Wm. C. P. TAPPER, M.I.E.E., Borough Electrical Engineer and Manager, No. 27, Osborn Street, Whitechapel, E. 1, upon receipt of a deposit of five guineas for each section. Deposits will be returned to *bona fide* tenderers after the tenders have been considered by the Council. Additional copies, with drawings, may be obtained upon payment of the sum of one guinea, which will not be returned. Copies of the specifications and drawings may be inspected at the above-mentioned address by appointment.

Tenders, on the form supplied, endorsed "Tender for Section 'A' or Section 'B,'" as the case may be, must be delivered, signed, sealed and addressed to the Chairman of the Electricity Supply Committee, at No. 27, Osborn Street, Whitechapel, E. 1, not later than 8th June, 1922.

The Council do not bind themselves to accept the lowest or any tender, and the acceptance of any tender is subject to the sanction of the Electricity Commissioners to the necessary loan being obtained.

GEO. W. CLARKE,
Municipal Offices, Town Clerk.
Raine Street,
Old Gravel Lane, E. 1,
2nd May, 1922. U 134

METROPOLITAN BOROUGH OF HACKNEY.
ELECTRICITY DEPARTMENT.

The Council of the Metropolitan Borough of Hackney are prepared to receive

Tenders for the following

PIPEWORK and VALVES comprising:—

Part I.—Steam Pipes, Valves, Steam Receiver, etc.
Part II.—Exhaust Pipes, Vapour Pipes, Valves, etc.
Part III.—Drain Pipes, Valves, Traps, etc.
Part IV.—Blow-down Pipes, Valves, etc.
Part V.—Boiler Feed Pipes, Valves, etc.
Part VI.—Condensing Water Pipes, Valves, etc.
Part VII.—Water Supply Pipes, Valves, etc.
Part VIII.—Hotwell Connections, Valves, etc.
Part IX.—Steel Air Trunks.
Part X.—General.

Tenderers must Tender for the whole of the work specified.

General Conditions, Specifications and Drawings and Form of Tender may be obtained from the Borough Electrical Engineer, 236, Mare Street, Hackney, E. 8, on and after the 14th day of May, 1922, on making a deposit of Five Guineas, which sum will be refunded to *bona fide* Tenderers after the Tenders have been adjudicated upon. Extra copies of the Specification may be obtained by *bona fide* Tenderers at a charge of One Guinea each, which sum will not be refunded; one copy of the Specification will be deposited with the B.E.A.M.A.

Tenders, enclosed in envelopes sealed with sealing-wax, and endorsed, "Tender for Pipework," must be delivered by the persons tendering, or their authorised representatives, to the Chairman at a meeting of the Establishment and General Purposes Committee of the Council, to be held at the Town Hall, Mare Street, Hackney, E. 8, on Wednesday, the 14th day of June, 1922, at Seven p.m., or sent by registered post, addressed to the Chairman of the Committee, so as to be delivered not later than seven p.m. on Wednesday, the 14th day of June, 1922. Tenders sent otherwise will not be considered.

In the case of all workmen to be employed by the Contractor, the Contractor will be required to pay wages at rates not less and to observe hours of labour not more than those recognised by the Trades Unions and in practice obtaining in the District where the work is carried out.

The Council do not bind themselves to accept the lowest or any Tender.

R. H. B. TEE,
Town Clerk.
Town Hall, Mare Street,
Hackney, E. 8.
28th April, 1922. U 114

DEVELOPMENTS IN THE USE OF PARAFFIN FOR COAST LIGHTING.

THE illuminants by means of which modern coastal lighting is effected may be divided into the three groups of oil, electricity, and gas, the last of which, comprising coal, oil and acetylene gases, may be burnt either in the form of an open flame or as a bunsen flame with an incandescent mantle. Its application is, however, chiefly confined to buoys and beacon lights, or to unwatched and semi-watched lights of a comparatively unimportant character.

Where lights of high power are exhibited and are of sufficient importance to warrant a constant watch being kept at night, electricity and paraffin oil are the usual illuminating agents, and though the use of electricity both with the arc and gas-filled filament lamp is by no means limited, the high cost of generating current at the lighthouse does not justify the increase of illumination obtained compared with paraffin oil. Except when electric power can be procured cheaply from a local supply, the most economically efficient method of lighting is undoubtedly by paraffin. It is with this method that it is now proposed to deal.

The use of oil as an illuminant has been known from time immemorial, so that no introduction in this respect is needed, but its general adoption for the purposes of lighthouse illumination does not date back more than 200 years, although Hakluyt, in his book of voyages, relates that "at the mouth of the Bosphorus there is a turret of stone upon the mainland 120 steps high, having a great glass lanthorne in the top, four yards in diameter and three in height, with a great copper pan in the midst to hold oil, with 20 lights in it, and it serveth to give passage into the Strait in the night, to such ships as come from all parts of those seas to Constantinople." This, however, was probably only an isolated instance of oil being used for coast lighting. The earliest attempts to provide a guide for the mariner at night were made by lighting bonfires on headlands and by coal, wood or pitch fires in open grates and swinging baskets known as "chauffers" placed on the tops of high towers. In 1696, Winstanley introduced a chandelier with tallow candles into the lantern of his tower on the Eddystone rock, a system which was adopted elsewhere, and even Smeaton burned candles in his later Eddystone tower.

All these can have been of little real value to the sailor, but nevertheless practically no advance appears to have been made in the production of an effective maritime light until the latter end of the eighteenth century, when, in 1782, M. Argand invented a burner in which he contrived to burn oil from a circular wick with a central air current running through it, an invention on the principle of which for many years subsequently all lighthouse burners were designed.

In order to follow properly the development of the oil burner, it will be necessary to make a brief survey of the various types of optical apparatus employed for lighthouse illumination up till the present time, for it was the improvements in the latter which, to a large extent, governed the developments of the former.

To provide a well-lighted coast, lights must be exhibited at such points along it as will ensure a safeguard to the mariner at night, and whether that light be a landfall or making light, or whether it be a coastal light or one marking a dangerous rock or sunken shoal, or only a harbour light, the guiding beam must not only be of such power as is demanded by its position, but it must also display some characteristic or distinguishing feature to make it clearly recognisable from all other lights in its vicinity, and so form a reliable object on which bearings from the sea may be taken.

The production of character may be effected in three main different ways: Firstly, by allowing the light to be continuously visible; secondly, by eclipsing it for short periods at regular intervals; and, thirdly, by exhibiting the light for a time and following it by a period of darkness of longer duration. These three characters are known successively as fixed, occulting and flashing, and from them further distinctions can be introduced by grouping, *i.e.*, by having two or more occultations or flashes in quick succession, and also by colouring the light by means of red and green glass.

Whichever type is employed, however, the useful collection and direction of the rays which emanate from the source of light is entailed, and this involves the application of the optical principles of reflection and refraction to the design of lighthouse apparatus. On these fundamentals three systems are based: (*a*) The catoptric, in which the rays from the source of light are directed by reflection from some reflecting agent, (*b*) the dioptric, whereby the rays are refracted or bent on passing through a transparent medium, and (*c*) the catadioptric, a combination of both the catoptric and dioptric systems.

Prior to the year 1763 lenses were used for burning glasses, and even improperly in lighthouses, but it was not until that date that the laws of optics were correctly applied to lighthouse illumination. According to Mr. Hutchinson, Dockmaster of Liverpool, in his "Practical Seamanship," published in 1777, lighthouses established at the Mersey in 1763 were fitted with reflectors formed of plates or facets of silvered glass and fitted, as recorded "as nearly as they can be to the parabolic curve."

The optical properties of the paraboloidal reflector are of the catoptric group, and, as is known, are such that if a point source of light is placed at the focus all rays from it falling on the reflecting surface will after reflection be sent out in a direction parallel to the axis. No point source can, however, exist practically, and owing to the size of the illuminant the resultant beam will possess an angle of divergence dependent upon the dimensions of the source of light, that is, the beam will spread out on either side of the axis. This angle of divergence is twice the angle whose sine is half the projected width or height of the source of light divided by the focal distance, and exists in all apparatus, whether catoptric, dioptric or catadioptric.

To the lighthouse engineer divergence is of practical value, and although Mr. Thomas Stevenson in his "Lighthouse Construction and Illumination," remarks that "if the most intense part of the emergent beam be pointed to the horizon, very nearly one-half of the whole light is lost above the horizon," yet with the advent of aerial traffic and the ever-increasing necessity for aerial lighthouses, this portion of the beam will be by no means wasted.

Taking advantage of this angle of divergence, the earlier method of producing a fixed light was by arranging a number of paraboloidal mirrors around a circular frame so that the edges of the beam from any two neighbouring sources of light overlapped, thus giving a horizontal beam visible 360 deg. in azimuth. Revolving lights were also constructed by fixing a number of reflectors on a vertical shaft with their axes parallel to one another; the shaft was then made to rotate, and with it would revolve the beam of light, with the consequent production of flashes. This type of lighthouse illumination is now almost entirely superseded, although the catoptric system for flashing lights is still employed to a considerable scale on light vessels. The majority of the reflectors now used are silvered copper of 21 in. aperture and 3 in. focal distance, with a two-wick oil burner in focus.

In 1822 a new era in lighthouse illumination was heralded by the invention of Augustin Fresnel, who designed an optical apparatus for producing a flashing light. This apparatus was built up of a small lens with a number of annular rings known as refractors placed concentrically with it. These latter were in reality the outer edges of lenses, each larger than the other, with their centre as it were removed to avoid the use of a lens of such thickness as would otherwise have been necessary had it been made in one piece. The faces of these compound lenses were ground in such a manner that all the rays of light emanating from their common focus emerged after refraction along lines parallel to the axis of the lens. Fresnel then proceeded to apply this idea to the production of a fixed light, and originated what is known as the cylindric refractor, an apparatus consisting of a circular belt with concentric refracting rings above and below it. In this manner the light could be seen from any point around the horizon, for the rays underwent refraction only in the vertical plane.

He then conceived a yet further improvement by the addition of triangular internal reflecting prisms to his cylindric refractor, an invention which was further developed by Mr. Thomas Stevenson, who applied it later to Fresnel's lens. When a ray of light internally incident on the surface of a glass medium meets that surface at an angle to the normal greater than a certain angle, known as the critical angle, the whole of the light, instead of passing out into the rarer medium and being refracted, is totally reflected internally. By the proper grinding of these prisms the rays of light from the focus of the apparatus can be made to undergo firstly refraction, then reflection, and finally refraction again, until they emerge in the desired direction.

These developments by Fresnel and Stevenson in the use of lenses, refractors and reflecting prisms still form the basis of all modern lighthouse optical apparatus. These apparatus are divided into groups or orders, of which the first and second orders are generally adopted in this country, and the second and third orders abroad, where lights of high power are required, the smaller orders being used for less important positions. The classification is as follows:—

	Focal Distance. mm.
Hyper-radial	1,330
First Order	920
Second Order	700
Third Order	500
Small Third Order or Large Fourth Order	375
Fourth Order	250
Fifth Order	187·5
Sixth Order	150

Having thus briefly described the general uses of lighthouse optical apparatus, the development of the oil burner up to the present time can now be traced.

As soon as Fresnel had designed his dioptric lens, he realised that Argand's one-wick lamp possessed insufficient illuminating power as a source of light for it and, with the help of M. Arago, he constructed multiple-wick burners with two, three and four concentric wicks, each separated from the other by an annular space to allow of the double current of air being supplied to the flame. To Fresnel's four wicks Mr. Allan Stevenson added a fifth, and later, on the introduction of mineral oil, Sir James Douglass increased the number to as many as 10. All these burners, consuming large quantities of oil, relied essentially on the supply being kept at a definite constant level below the tops of the wicks, so that capillary action might take place at a sufficient speed to ensure the production of the maximum amount of illumination of the flame. To attain this object the oil was fed either hydrostatically from an overhead reservoir, or by pressure from a lamp or container placed below the burner.

Up till nearly the middle of the nineteenth century fish oils were chiefly employed for illumination, that generally adopted for lighthouse purposes being sperm, obtained from the head of the sperm whale. In the year 1832 the French were making trials with "colza," a vegetable oil obtained from the seed of the rape plant, a small wild cabbage. This oil, giving as good results as "sperm," and coming into the market at a considerably cheaper price, was eventually adopted by the Trinity House in 1845, and employed by them in all their lighthouse and lightship burners for over 25 years. During this period the discovery was made, in America, of petroleum in the form of crude oil; and in France and Scotland a process of obtaining crude oil from shale was being perfected, and derived from both of these, mineral oils were being introduced of the paraffin series with a high percentage of hydrocarbons and consequent increase of illuminating power.

During the year 1865 a light mineral oil, known as lighthouse paraffin, was being manufactured under Young's patents from Scottish shale in sufficient quantities to warrant its use for lighthouse purposes, and shortly afterwards experiments were carried out by Sir James Douglass with a view to adapting Trinity House burners to its use. By lowering the constant level of supply to counter-

balance the quicker capillary action of this oil, and by the addition of a deflector and re-adjustment of the burner tips around the concentric wicks to obtain a better distribution of the air currents to the flames, Sir James succeeded in his object, and in 1873 "colza" was rapidly being superseded at all shore stations. Previous to this, Captain Doty had produced on somewhat similar lines burners capable of consuming mineral oil, and these were subsequently adopted by the French and Scottish lighthouse authorities.

Since suitable mineral oil of a higher flash point than 145 deg. F. could not be procured at the time, Sir James Douglass, fearing danger from fire, would not recommend the use of oil in burners at rock lighthouses or on light vessels. It was not until 10 years later, when a heavy mineral oil with a flash point of 250 deg. F. was produced from American petroleum that "colza" was finally altogether supplanted. This heavy oil is still the

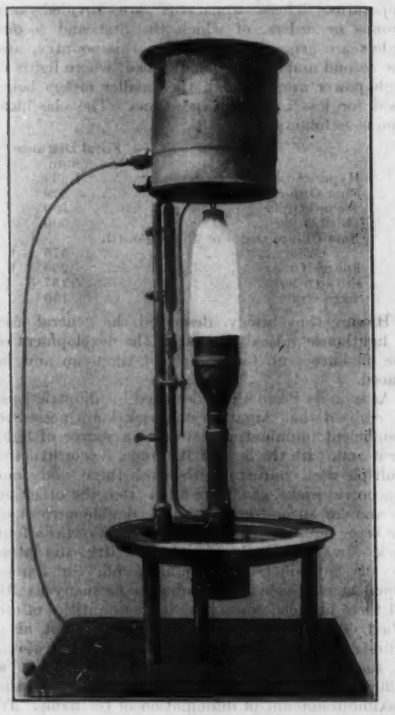


FIG. 1.

illuminant on lightships in the wick burners of the catoptric reflectors, but in lighthouses light mineral oil, known as lighthouse paraffin, obtained from the Scottish shale, is now universally used in the British Isles. It is required by specification to have a flash point of 150 deg. F., and a specific gravity of 0·805.

In 1901 wick burners, as far as lighthouse illumination was concerned, gave place to the method of vaporising oil and burning it as a bunsen flame with an incandescent mantle. As a result of this introduction at the present time, except in a very few instances, all lighthouse burners consuming paraffin are of the incandescent mantle type. The bunsen flame was obtained by vaporising the oil in a retort by the application of externa. heat, and mixing the vapour thus obtained with sufficient air to form the non-luminous heating flame required.

The first attempt in this country to apply this system to lighthouse illumination was in the middle of 1900, when Mr. Arthur Kitson brought to the notice of the Trinity House his oil burner using an incandescent mantle. This burner, which was of the type where an overhead vaporiser enclosed in a hood screen was heated by the flame over the mantle below, was installed in Lowestoft lighthouse, but did not prove itself capable of practical adoption, with the result that Sir Thomas Matthews then developed on the Kitson principle a new burner which contained such considerable improvements both in construction and illuminating power that in a very short time the complete supersession of nearly all the wick burners on the English coast was brought about.

In the Matthews burner the vaporiser consisted of two loops of brass tube brazed into the sockets of a small brass union piece. The pre-heating of this burner, which was of two types, single-mantle and triple-mantle, was effected by means of the flame from a paraffin blow lamp applied to the vaporiser. A single mantle Matthews burner is shown in Fig. 1.

About the same time the French lighthouse authorities evolved a burner on the same principle, but instead of using a hood screen they adopted a "U"-shaped vaporiser carried vertically around the mantle, with a methylated spirit wick lamp for pre-heating. This was discarded at a later date in favour of an improved type.

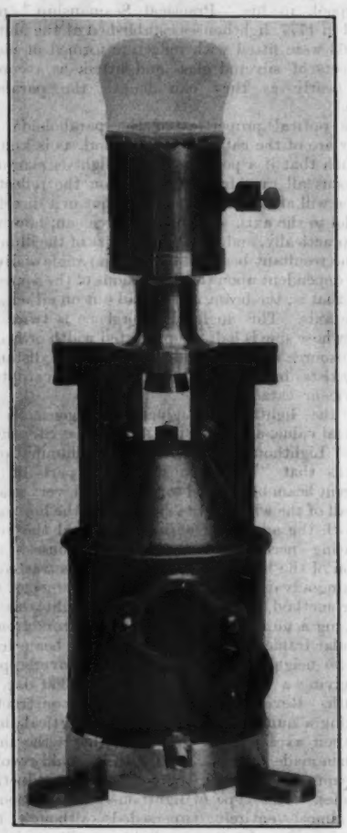


FIG. 2.

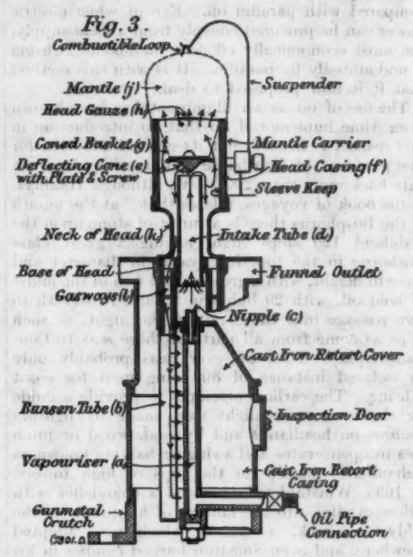
In efficiency and reliability as an illuminating unit the Matthews burner was equal to any other type of collodion mantle burner, and it has successfully stood the test of time for nearly 20 years in practically all the lighthouses on the English coast and in many other parts of the world. The cost of maintenance and repair of the vaporiser has, however, always amounted to a considerable sum annually, and became a subject of very serious consideration during the great war, as a result of the increasing cost of labour, the poor quality of material then available, and a prolonged strike of coppersmiths. As a consequence Mr. D. W. Hood, who, in 1915, had become engineer-in-chief to the Trinity House, decided that a new type of burner would be the only satisfactory solution of the difficulty. The main point Mr. Hood decided upon as his objective was to combine maximum intrinsic brightness with the three essential qualities of simplicity of construction, economy in maintenance and easy manipulation.

Unlike the "Matthews" and "Lux" burners, which as types of overhead vaporisation have stood alone, nearly all incandescent oil burners vaporise the paraffin below the nipple by gas withdrawn from the burner head; and in view of the probable need of aerial lights in the immediate future, and the advantage to be gained by having the upper portion of the mantle capable of being viewed entirely unobstructed from the sky, the use of the overhead type of vaporiser was ruled out, and it was decided to vaporise the oil by the generally adopted method of the subsidiary flame.

The new "Hood" burner is illustrated in Figs. 2 and 3, and consists of two main parts, viz., the retort containing the vaporiser, nipple and bunsen tubes, and the burner head. Its action will be more fully understood from the diagram in Fig. 3 and the following description.

The pre-heating of the vaporiser (*a*) is effected by methylated spirit in an open bath placed beneath the burner. When sufficiently hot, paraffin at a

Fig. 3.



pressure of 60 lb. per square inch is forced into it and, heated by small flame jets from the bunsen tubes (*b*), arrives as vapour at the nipple (*c*), through which it issues as a conical jet and passes into the head by way of the intake tube (*d*), drawing in with it a correct proportion of air. The combined vapour and air then impinge on the deflecting cone (*e*), and mix in the head casing (*f*) to form a bunsen gas of which the greater portion passes through the perforated coned basket (*g*) and head gauze (*h*) into the mantle (*j*), which it renders incandescent. A very small portion, however, due to the pressure of gas in the head, passes downwards into the annular space enclosed between the intake tube (*d*) and neck of the head (*k*) and through the gasways (*l*) into the bunsen tubes (*b*), whence the gas for the jets for heating the vaporiser is supplied.

The burner is as far as possible foolproof and admits of no adjustment whatever, it being thought advisable rather to fix the air supply than to fit an adjustable regulator with the inevitable possibility of its misuse. The vaporiser, which is L-shaped so as to keep the supply pipe connection out of the flame of the pre-heating lamp and beyond the influence of the flames from the bunsen tubes, is of nickel steel containing 3 per cent. nickel, and in the rough is a stamped forging. From this state it is turned, bored and screwed, and when complete forms a vaporising tube from which all joints except the two at the nipple and supply pipe connection have been eliminated. The nickel steel is hard and durable and specially adapted to withstand the prolonged heat strain which a vaporiser is called upon to undergo. It gives a life of well over a year. The nipple is of mild steel with a view to preventing the possibility of seizing taking place, the joint between it and the vaporiser being of the coned type. This has proved very effective.

The crutch is of gunmetal, and the retort casings

are fine iron castings made by the Carron Iron Company, of Falkirk. They embody the funnel outlets for the waste gases from the interior of the retort, and the throats into which the head and bunsen tubes are fitted and through which the gas for the bunsen jets passes from the head to the latter. An inspection door for observing whether the bunsen jets are functioning properly is provided in the lower or cylindrical casing.

The bunsen tubes are of brass, with three vertical rows of holes all equally spaced but graduated in diameter with the larger holes at the bottom in order to vaporise the paraffin as quickly as possible.

The brass head consists of three parts:—(1) The combined base and intake tube; (2) neck; and (3) head casing containing head gauze, coned basket and deflector and supporting sleeve. The head gauze is nickel steel wire, and the coned basket is constructed out of perforated brass sheet, and substitutes the usual internal gauze necessary in all such burners to prevent back firing. To the bottom of this basket is fitted the deflector. The curved neck connecting the base of the head to the head casing, also provides a path between itself and the intake tube for the gas which flows into the bunsen tubes. The gasways are designed for paraffin of a flash point of about 150 deg. F., but by reducing the area of these proportionately the burner can be adapted to work equally well with oil of a lower flash point.

The air and oil containers are those used with the "Matthews" burner, and consist of two receivers, the smaller one for paraffin and the larger one, about treble the capacity, for air, each connected to the other and through a valve to the burner by piping. They are fitted with pressure and oil gauges, and require no special comment.

The cleaning of the burner, one of the essential factors necessary for good working, is of an easy nature, and consists of drying out all wet paraffin from the vaporiser, scraping out the carbon deposits which accumulate in it during the vaporisation of the paraffin, and boiling the whole of the internal parts of the head in potash to remove from them the tarry matter which becomes deposited during running. In lighthouse practice the addition of a little polish and black lead on the exterior is adopted, but is a matter of discipline only and in no way affects the efficient working.

During the earlier trials of this burner the mantle used was of the collodion type, but since both the total intensity and the intrinsic brightness obtained gave such satisfactory results, and showed so marked an improvement over those of earlier types of burners, Mr. Hood subsequently turned his attention to the autoform mantle. This produced much better results. In this connection the requirements were submitted to the Welsbach Company, and, with valuable assistance from Mr. Benjamin Bark, their works manager, an autoform mantle was finally devised giving about 330 English candles per square inch of projected area of vertical section, and capable of withstanding the high pressure from the bunsen flame.

This mantle, as its name suggests, assumes its own shape when burnt off. It is manufactured from Viscose silk, knitted in the usual way, and sewn to close one end. The lower or open end is lapped, and has a stout asbestos thread inserted round it, so as to enable the mantle to be tied to the mantle carrier, while at the upper or closed end there is a loop of combustible material, by which the mantle is hung from the suspender until it has been burnt off on the burner. The mantle is impregnated with a mixture of thorium and cerium, but receives special treatment to enable it to withstand the pressure from the bunsen flame. Until it is placed on the burner it is quite pliable and can be packed for transport without any special care. It differs from the collodionised mantle inasmuch as the latter is made of ramie, burnt off, and given its shape when first made. This burning off necessitates collodionising to make it rigid, as otherwise it would be impossible to transport it, but even in this state it requires special boxes and care to prevent breakage.

Preparatory to use, the autoform mantle is hung at the top from a suspending rod fitted to the brass mantle carrier, and at the bottom is tied to the top of the carrier, around which are several bossed holes with a central groove, wherein lies the fixing cord, running through them, the rough edges of the holes forming an additional gripping surface for keeping the mantle in place.

To illuminate the mantle the burner is first lighted, and then the carrier to which the mantle is fixed is lifted by a pair of tongs and brought down slowly and centrally from the summit of the flame on to the shoulder around the head casing of

FIG. 4.

the burner, where it rests. At the commencement of this operation the mantle is blown out by the flame to its fullest extent, and as it is lowered the burning off process takes place, that of the bottom part being effected through the holes in the top of the carrier; then, shrinking very gradually, it assumes its correct shape, after which the top loop burns away and the mantle is left held entirely by the fixing at its base, so that the suspender can be removed, and an illuminating source without any obstruction whatever either for the mariner or for the aviator remains.

As mentioned above, in order to produce an efficient beam of light, the optical apparatus and the source of illumination must be considered as inseparable units, and therefore to meet the requirements of both past and present lighthouse practice Mr. Hood has developed his burner in four sizes, one of which is illustrated in Fig. 4. The largest of these has a mantle of 100 mm. diam., and the smallest 35 mm., the two intermediate sizes having mantles of 75 mm. and 50 mm. diam. respectively. The determination of these different sizes was decided by three main considerations:—(1) the length of flash required in flashing lights, which is governed by the speed of revolution of the optical apparatus and the divergence of the beam; (2) the position of the focus of the reflecting prisms, which, in the older types of apparatus was not at the focus of the lens or refractor, but was placed behind it in the case of the upper prisms and in front in the case of the lower ones; and (3) the maximum width of mantle necessary for a fixed light. The size of burner generally in focus in first and second order flashing lights is that with the 75 mm. mantle, and in first order fixed lights the burner with the 100 mm. mantle. For smaller flashing lights the 50 mm. and 35 mm. burners are adopted, and the 75 mm. and 50 mm. burners for fixed lights other than first order, while a modification of the retort casing of the smallest burner has rendered it suitable for use with catoptric lights.

The shape aimed at in the design of the new mantle was an approximation to a sphere, as it was found that this gave the maximum intrinsic brightness. Although higher total intensities can be obtained if the size of the mantle is increased, yet when this is done the intrinsic brightness falls away, while to lessen the size is to reduce both total intensity and intrinsic brightness. The mantles of the four sizes of burners have projected areas of 11 sq. in., 7 sq. in., 3·5 sq. in. and 2 sq. in. respectively, and when illuminated possess, according to the size of the mantle, an intrinsic brightness of 300 to 330 candles per square inch. This exceeds anything hitherto obtained from any petroleum vapour burner, and represents an increase of 100 per cent. over the intrinsic brightness of a collodion mantle, which approximates to 160 candles per square inch, and nearly 1,300 per cent. over Fresnel's original four-wick burner, as may be seen from the subjoined table, which has been compiled to illustrate the gradual improvement in oil illumination since his day.

The intensities of the Hood burner were obtained from photometric readings taken in the experimental room at the Trinity House with a Simmance-Abady flicker photometer, the standard light unit being a 10-candle Vernon-Harcourt Pentane lamp. Higher intensities than those quoted have several times been observed, but they were undoubtedly due to a combination of favourable conditions which cannot always be maintained.

As regards the economy in maintenance the new burner has already proved itself a great advance on previous types, repair costs being very greatly reduced. At Dungeness and North Foreland, the former being the experimental lighthouse station for the 75 mm., 50 mm. and 35 mm. burners and the latter for the 100 mm. size, the amounts spent in actual repairs for periods extending over 18 months are about one-tenth of the former expenditure. The consumption of mantles has also fallen, and as the keepers get more and more accustomed to their use it is expected that a saving of at least 50 per cent. will be made in this respect. In addition to the decrease in consumption of mantles,

No.	Type of Burner.	Diameter of Flame or Mantle at Focal Plane.	Height of Flame or Mantle.	Projected Area of Vertical Section of Flame or Mantle.	Intensity of Flame or Mantle.	Intrinsic Brightness, per Square Inch.	Intensity of Beam from Four-sided First Order Apparatus.
		in.	in.	sq. in.	Eng. candles.	Eng. candles.	Eng. candles.
1	Fresnel (four-wick) ..	3·86	3·60	9·76	230	23·60	64,000
2	Douglas (four-wick) old pattern	2·85	4·00	9·36	350	37·40	102,000
3	Douglas (four-wick) new pattern	2·12	3·50	6·43	350	54·43	149,000
4	Matthews (single mantle)	2·00	4·25	8·00	1,250	156·25	444,000
5	Hood, 50 mm.	2·15	1·95	3·50	1,150	328·57	895,000

however, a still more valuable saving has been effected in transport owing to their flexibility. It is an easy matter to pack 100 autoform mantles in the same space as that formerly occupied by half-a-dozen collodion ones, which when sent abroad had each one to be packed separately in a tin case.

From the foregoing description, it can be judged that in the new standard Trinity House service burner devised by Mr. Hood an oil burner has been produced embodying to an exceptional degree the three essential features of brightness, economy in maintenance and simplicity. In conclusion, it may be stated that other lighthouse authorities have been very quick to recognise the value of the auto-form mantle, and are already modifying their burners to enable these soft mantles to be used.

THE INTERNATIONAL RAILWAY CONGRESS AT ROME.

(*Continued from page* 528.)

THE real business of the Congress began on April 19, when the various sections met in the Palace of Fine Arts to discuss the questions upon which papers had been prepared by the respective reporters. The Congress is divided into five sections as follows: Section I, Ways and Works; Section II, Locomotives and Rolling-Stock; Section III, Operation; Section IV, General; and Section V, Light Railways. The sections sat simultaneously, each in one of the art galleries leading from the central hall, and the arrangements made were not satisfactory for hearing.

It will be convenient to dismiss at first some of the special events of the programme, and to proceed afterwards to the work of the several Sections as far as space allows in this issue.

In the evening of Wednesday, April 19, the delegates to the Congress and the ladies of the party were the guests of the Italian Government, at a banquet which was held in the Baths of Diocletian. The immense hall, constructed more than 16 centuries ago, and having the proportions of a cathedral, was brilliantly illuminated by electric light, and formed a most impressive setting for the feast. Over 1,300 guests were present.

VISIT TO THE RUNNING SHEDS AT S. LORENZO.

On Friday afternoon, April 21, a special train took such members of the Congress as were interested to the locomotive running sheds at S. Lorenzo, in the suburbs of Rome. The sheds are completely circular in plan, the chief point of interest being the central turntable, which was operated pneumatically. A steel plate bracket had been attached to the turntable at the end of one side, this bracket carrying a compressed air motor driving one of the turntable wheels through reduction spur gearing. In the normal working of the turntable, a locomotive ran on to it, and the Westinghouse air pump was then coupled to the air motor by a flexible hose. The operation of the air pump thus caused the turntable to rotate. An air receiver, carried on the table, contained enough air under pressure to drive the table for a short time if no locomotive was on it, and a hose connection near the edge of the pit enabled the receiver to be filled from the service mains when required.

After inspecting the turntable, the party were invited to examine a new type of locomotive valve gear invented by Signor Caprotti. A locomotive, standing in the yard, had been opened up so that the mechanism of the gear could be seen, and a wooden staging erected around the front of the engine rendered inspection convenient. Briefly stated, the valve gear consists of four drop valves to each cylinder operated by cams and bell cranks. The cam shaft runs transversely across the upper side of the cylinder, and is driven by two sets of bevel gear from one of the driving axles. A helical spline arrangement permits the relative position of the cams to be changed, so that cut-off may be varied and reversing accomplished. The gear is claimed to be an improvement on the Lenz arrangement and to bring about a material economy in steam. We shall illustrate and describe this gear more fully in a future issue.

A further object of interest was the installation for economising fuel by saving the heat in the water of locomotives returning to the sheds. Similar apparatus, which is made by the Maison Guiseppe De-Micheli and Co., of Florence, Italy, is also installed in the running sheds at Turin and Venice, and several other plants are in course of construction in Italy. The hot water from the incoming engine is passed through a counter-current heat interchanger, where its temperature is reduced from about 145 deg. C. to about 90 deg. C. Thence it goes to a filter, and finally to a large tank. It is stored in this tank at a temperature of about 60 deg. C., and used for washing-out purposes, being delivered for this duty under a pressure of 120 lb. per square inch by a centrifugal pump. The clean water which is to be used for filling the boilers of engines leaving the sheds, passes first through a coil submerged in the wash-water tank, and thence to its own tank. A motor-driven centrifugal pump takes it from this tank and passes it through the heat interchangers, whence it flows back into the tank. By this means the water in the tank is maintained at a temperature of about 80 deg. C., and it is pumped from the tank as required for filling the boilers of out-going locomotives. It is claimed that a plant capable of dealing with the water to and from 15 locomotives per day will effect a saving of at least two tons of coal per day, by the recovery of the waste heat in the boiler-water.

EXCURSION TO TERNI.

On April 22 a large number of delegates and ladies made an excursion to Terni, about 58 miles from Rome, a special train being run for the party. The object of the visit was to inspect the works of the Italian Calcium Carbide Company which has concessions for the use of the water power available from the rivers Velino and Nera, which unite near Terni, and afterwards flow into the Tiber. This company has made four developments of the local water power, at Collestatte and Papigno on the Velino, with falls of 152 m. and 194 m., respectively, and at Cervara and Nera Montore on the Nera, with falls of 23 m. and 25 m. respectively. At Collestatte 14,500 h.p. are developed at 6,000 volts for the manufacture of calcium carbide, cyanamide and sulphate of ammonia. At this establishment some striking experiments with liquid air were shown to the visitors, and a tour through the works was subsequently made. The Papigno development amounts to 60,000 h.p. Energy is generated at 6,000 volts, part of which is stepped up to 60,000 volts for transmission to Rome. Another 15,000 h.p. are generated at 65 volts for direct use by the carbide furnaces. The Cervara station, with a low head only, develops 12,000 h.p. at 3,750 volts, the pressure being stepped up to 27,000 volts for transmission. The various plants were somewhat hurriedly inspected, free access to every part being permitted to the party, who were merely cautioned by numerous notices, "Prenez garde à vôtre incolumité," which were erected with good intentions. In visiting these works the delegates had, of course, to pass close to the magnificent falls of Marmore, of which an excellent view was obtained. Works for making calcium carbide, cyanamide, &c., are more in keeping with the surroundings of a "black country" than with the extraordinary natural beauties of the Marmore Falls, but fortunately the two sights do not strike the eye simultaneously. A hydro-electric plant, with good architectural features, as many have, may even enhance the view of a waterfall, but chemical works are better out of sight. On the journey to and from Terni, those interested in ancient history had a fine view of Mount Soracte, mentioned by Horace, and of the arch of the famous high-level bridge built by Augustus to carry the Flaminian Way over the river at Narni.

CONSTRUCTION OF THE ROAD BED AND TRACK.

Section I of the Congress devoted part of one of the early sittings to the consideration of the arrangements to be adopted in constructing the road bed and the track in view of the increased weight of locomotives and speed of trains. The Section sat under the presidency of Mr. F. Bruneel, the Belgian Minister of Railways, Marine, Posts and Telegraphs, and a member of the Permanent Commission. Five reports were considered simultaneously, the reporters being Mr. E. F. C. Trench, of the London and North Western Railway, for Great Britain; Messrs. H. U. Mudge, President of the Chicago, Rock Island and Pacific Railway, and Chas. H. Ewing, Vice-President of the Philadelphia and Reading Railway, for America; Mr. Karl Ahlberg, of the Swedish State Railways, for Sweden and Norway; and M.M. Henry and Candelier, of the Eastern and Northern Railways of France, respectively, for other countries. We subjoin summaries of these reports:—

In his report on this subject for Great Britain, Ireland, India, South Africa, Australia and New Zealand, Mr. E. F. C. Trench, Engineer-in-Chief, London and North Western Railway, pointed out that in Great Britain maximum speeds were no greater than formerly, but that the number of heavy trains attaining these had considerably increased. Passenger trains ran to 500 tons, and freight to 1,500. Twenty tons still remained the limiting axle load, but the total weight of engines had increased. In India the maximum speed for the 5 ft. 6 in. gauge was 60 m.p.h., and 40 or so for the metre gauge. Train loads ran to 600 tons for passengers, and 1,400 tons for freight. The axle load was limited to 17½ tons. In South Africa freight train loads were up to 1,428 tons, engine and tenders ran to 130 tons, though the limit per axle was 17 tons. In South Australia loads and speeds were less, and the axle limit was 12½ tons. In New Zealand, though train loads and engine weights had greatly increased, the limiting axle load was still 13 tons.

In general construction the formation width for double lines was still 30 ft. for embankments and cuttings, the formation being usually cambered 6 in., or given a definite slope. More care than formerly was taken with drainage. In cuttings pipe drains were laid covered with stone filling, instead of using open drains. In mining districts subsidence often required special measures to be taken. Improvements in track had largely been matters of detail. English engineers still adhered to the chaired road, which in economy of maintenance and life equalled any other type. The flat-bottomed rail was suitable where timber was plentiful, and quick construction desirable. The bull-headed rail gave a road in which rails, sleepers and fastenings all had about the same life. This, with creosoted sleepers, on the London and North Western Railway was about 20 years for the main line. Using screw spikes, 400 to 800 yards of this road could be relaid in a week without interfering with traffic. The chaired road was developed in connection with the use of soft wood sleepers.

Bottom ballast should be of hard stone passing a 6-in. ring, while top ballast should pass a 2-in. ring. It should be clean and at least 12 in. deep under sleepers. Granite was best. Mechanical tampers had made little progress and shovel packing was, as a rule, preferred with stone chippings. The beater often resulted in the sleeper being packed up on a few points only. The tendency was to increase the number of sleepers, but packing space of 1 ft. 6 in. was required between them. Extra wide sleepers were placed either side of joints. The standard sleeper was 9 ft. by 10 in. by 5 in., but 8 ft. 6 in. sleepers were used without harm arising. They were formerly of Baltic pine, but now were of pitch pine, Oregon pine, red wood, and so on. Steel sleepers showed no increased use. India used pot sleepers, but wood and steel were replacing these.

In Great Britain rails had not increased in weight lately and ran to 95 lb. to 100 lb. per yard for main lines. The British standard sections were commonly adopted, but there was a demand for rather harder material. Rails were allowed to wear down to 80 lb. or so before being replaced. They were usually 45 ft. long, some lines using 60 ft. rails. In India 100 lb. rails with the chairs, and 80 lb. to 90 lb. flat-bottomed rails were used, 30 ft. to 40 ft. long. The English chair gave about 115 sq. in. bearing on the sleeper, and weighed about 45 lb. to 54 lb. each. The treenail and spike were falling into disuse for the chaired road, and through bolts and coach screws were being adopted instead, though spikes were used for flat-bottomed rails. Steel keys were used experimentally; teak was preferred for wooden keys. The standard fish-plate in England was 1 ft. 6 in. long with four bolts. In South Africa

and Australia they ran to 30 in., were of the angle type, and had six bolts. The general though not universal practice was to put joints opposite each other. In spite of the heavier traffic, with a good road, maintenance was no more difficult than formerly.

The report for Denmark, Sweden and Norway, on this subject, was drawn up by Mr. K. Ahlberg, chief engineer of the Construction Bureau of the Swedish State Railways. Mr. Ahlberg pointed out that while the weight of trains had not increased in Scandinavian countries to the same extent as in other European countries, it was probable the near future would see something of the kind occurring. The present limiting axle loads were Denmark 17 tons, Sweden 17·5 tons and Norway 16 tons. In Sweden an increase up to 20 tons was contemplated. In Denmark and Sweden the maximum speed allowed for passenger trains was 56 m.p.h., and in Norway 37 m.p.h. For freight trains the maximum was 37 m.p.h. These speeds were for straight track and curves of large radius. The fastest passenger locomotives were capable of 62 m.p.h. With regard to the road bed, running was facilitated and costs reduced by laying out proper curves and gradients, although these often involved higher first cost. The endeavour was made to keep to 30 chains to 35 chains as the minimum radius for curves, and gradients of not more than 7 to 10 per 1,000. Transition curves were desirable, with a stretch of tangent between reverse curves.

Main line embankments were made 17 ft. 8⅝ in. to 19 ft. 0⅜ in. wide at the top, if low, the width being increased with the height. In earth cuttings the road bed itself was from 17 ft. 8⅝ in. to 18 ft. 4½ in. wide, not counting space for side drains. In order to reduce cost of construction in cuttings through rock, &c., masonry or concrete walls were used. On double lines, the lines were centred from 13 ft. 1½ in. to 14 ft. 7½ in. apart. With a view to preventing mistakes being made in estimating the character of ground traversed a geo-technical commission has been at work on the Swedish railways for some time. Good drainage increased the stability of earthwork. If sufficient firmness could not be secured by this means resort was had to mattress foundation work of faggots, &c., care being taken to see that these were placed under water or in moist soil. Low embankments showing signs of settling were strengthened by widening them with cinders carried down to firm ground. In making an embankment the work was carried 3 ft. 3 in. above the proper level to hasten settling, and charges of dynamite were exploded in the embankment to consolidate it. In the northern regions mistakes had been made in estimating the quality of the material, and it had been necessary to clear away the top material for a width of 9 ft. 10 in. and replace it with broken stones with cinders, &c., above. Clay was frequently removed and the place refilled with cinders or gravel. Road beds near water are laid at 3 ft. 3 in. above water level.

Ballast was laid to a depth of 1 ft. 11⅝ in., or 1 ft. 3⅞ in., and was usually of large pebbles without sand. Crushed stone was preferred, but was more expensive. Stone ballast retained its elasticity better than gravel, and where this material had replaced the latter, rail breakages had diminished. In re-ballasting with stone, some of the gravel might be left in order to prevent the foundation working up into the ballast. Sleepers of pine were employed, 8 ft. 6 in. to 8 ft. 10 in. long and from 5 in. to 6¼ in. thick and 8⅜ in. to 10¼ in. wide. Spacing was from 2 ft. 4⅜ in. to 2 ft. 6½ in. apart, with rails of 80 lb. to 90 lb. per yard. With the increase of load the spacing was being reduced, but could not be less than 1 ft. 3⅜ in. on account of packing. At joints the sleepers were brought nearer together, and double sleepers fastened by bolts had been employed. The creeping of rails was got over by bolting to the rails square plates which rested against the sleepers. Tie plates were used, especially with treated sleepers, to prevent the foot of the rail wearing the sleepers.

Mr. C. H. Ewing's report covered present American practice. He drew attention to the point that in America engine axle loads had increased 25 per cent. in twenty years, and now averaged a maximum of 66,000 lb. while the actual maximum was 75,600 lb. The average width of road bed for double track was 33 ft., with tracks centred 13 ft. apart on the straight. As regards drainage of cuttings it was often now customary to lay deep tile drains under side ditches, filling in above the tile drain with broken stone. Twelve inches of ashes were often placed over the sub-grade to prevent clay, &c., working up into the ballast. Twelve inches to 18 in. of top ballast were used. Stone ballast should pass a 2½ in. ring, but not pass a ½-in. ring. Burnt clay and gravel were also used. The depth of ballast under the sleepers should not be less than the distance between the centres of sleepers if the road bed were subject to deformation. Rails up to 135 lb. per yard were now used. One road using 130-lb. rails reported comparatively few broken rails; a life, on 6 deg. curves, 2½ times as much as that of 100-lb. rails; the possibility of increasing the carbon content from 0·69 for 100-lb. section to 0·75 for the 130-lb. rail; and finally that the track stood up better under heavy traffic. The A.R.A. 130-lb. rail had a height of 6½ in., base width of 6 in. and value of I of 77·4. A drop test was insisted upon. Sleepers were 8 ft. or 8½ ft. by 9 in. by 7 in. thick, hardwood being used where possible, as soft wood would not stand up to the wear of heavy tonnage. Plates between the rail and sleepers were 10 in. by 7 in. by ¾ in. thick; in some cases they were sloped. In tunnels the sleepers were often bedded in concrete, but in others ballast packing was used in a wide concrete trough. The plain-cut spike was most generally used. The screw spike was used in some cases, but had been given up in others. Fishplates were often used with depending flanges, but the angle plate was more common; this ran to a length of 30 in. to 36 in. when six bolts were used, or 24 in. to 28 in. when four bolts were adopted.

The report covering Europe and other countries except Scandinavia, the British Empire and America, was drawn up by Mr. Henry, of the Eastern Railway of France, and M. Candelier, of the Northern Railway of France. It was originally compiled in 1914, but a supplementary report was submitted bringing matters up to date in a few respects. The general opinion was that in the countries concerned increased traffic and loads had not caused much trouble with permanent-way save in exceptional places where the track was specially liable to deformation due to bad ground. In cuttings the ballast sank, and clay worked up through it owing to water being retained in depressions. Small side walls of ditches were pushed in. Ballast mixed with mud did not pack well, and joints became loosened. In embankments ballast penetrated into depressions through the collection of water at such spots. Increasing the weight of rail did not help very much, for though this would distribute a single load, it did little to assist matters in the case of a succession of loads as in the case of a train. On account of packing, sleepers could not be placed closer than 1 ft. 7⅝ in. apart. At joints they could be put closer if the bottom edges of the sleepers were chamfered. Wider sleepers were an advantage with increased depth of ballast, and if necessary, a good cushion or mattress over the clay, of fine sand, engine ashes, &c. The thickness of this layer should be in inverse proportion to the resistance of the ground, and in proportion to the spacing of the sleepers. A layer of slab concrete has been used, but trouble has been experienced by cracking. It should be at least 8 in. thick, sloped to one side, covered with 6 in. to 8 in. of slag and then 8 in. to 10 in. of ballast.

In order to ensure drainage the upper 6 ft. 6 in. or so in embankments should be of good material, placed on lower material, the top surface of which was properly cambered or inclined. In cuttings the depth from the underside of the sleepers to formation level should be 2 ft. 8 in. or 3 ft. 3 in. if the ground were bad. The Northern Company of France had tried a mattress of broken stone or clinker and slag cement deposited in a layer 8 in. thick, with a layer of 4 in. of ashes on the top. The concrete set as it absorbed moisture from the ground. Slab concrete pre-cast could be used, placed below the sleepers, with ballast between. In some cases the introduction of buried dwarf retaining walls had successfully stopped material crushing out laterally.

In the discussion which followed, Mr. Ahlberg stated that the method of hastening the setting of embankments when the subsoil was of soft clay, by loading the embankment temporarily with an extra yard or so of banking material, and also by exploding charges of dynamite in iron tubes inserted in the lower edge of the bank, had been used several times in Norway. The discussion turned a good deal on the question of using concrete rafts to strengthen the road-bed. There were not many instances of such work in Belgium, but on the Eastern Railway of France concrete rafts had been used in tunnels where the soil was of a soft nature. Professor Andreae, of the Zurich Polytechnic, considered that in tunnels the tendency of the subsoil was to become consolidated in the form of an inverted arch, and a concrete foundation would, therefore, not be satisfactory. Mr. Trench had never come across circumstances in England where a concrete raft was necessary. As regards rails, it was stated that of the six French railway systems, three used the flat-bottomed rail, and three, including the Paris Orleans Railway, used double-headed rails. The latter type of rail permitted the use of soft wood sleepers, but the Orleans Railway were nevertheless inclined to use the flat-bottomed rail, as this simplified the construction of points and crossings. Long rails were considered better than short ones, 18 m. being the standard length in Belgium, but lengths in excess of this were deprecated by one speaker. In Belgium tracks were laid with both square and broken joints. It was claimed that the broken-jointed track should be abandoned in favour of the square-jointed track on account of the tendency it caused for the rolling stock to oscillate. Another point discussed was whether rails were best laid vertical, or with an inclination of 1 in 20. The French railways had reverted to the latter practice, and the tendency seemed to be in the same direction in America, as it was found that vertical laying caused the formation of flanges after the rail had been in service for some time.

The conclusions of the delegates did not embody any very striking findings. It was agreed that during the past ten years the maximum speed of trains had not been increased, but that there had been a considerable increase in the number of high-speed trains, particularly goods trains. The weights of trains and the axle-loads had increased, but so far these increases had not appreciably increased the cost of ordinary maintenance. When repairing track, it was recommended (1) to increase the depth of the ballast; (2) to increase the number of sleepers; and (3) to increase the weight of the rails. In constructing new lines every effort should be made to secure stability of the road bed by efficient drainage, and by careful selection of the material used for the upper portions of embankments. Some engineers reported favourably on the practice of laying a raft of concrete under the ballast where the foundation was specially unstable, but others were doubtful of such practice, the cost of which, moreover, was very high. It was considered that the total thickness of top and bottom ballast should vary between 1 ft. and 2 ft., underneath the sleepers, according to the nature of the road-bed, the two layers being divided in suitable proportions. The bottom ballast should be permeable enough to permit free drainage for surface water, but sufficiently close to prevent clay working upwards through it. The best material for top ballast appeared to be hard stone or furnace slag broken to suitable size. When gravel was used it should include from 12 per cent. to 14 per cent. of broken pebbles, and from 20 per cent. to 25 per cent. of sand. The thickness under the sleepers should not be less than 5 in. to 8 in.

The spacing of sleepers should be, as a general rule, 1½ per metre of track when flat-bottomed rails were used. When chairs were employed 1⅓ sleepers per metre of track was sufficient. The minimum weight of rails should be 72 lb. per yard, and for the more important lines, rails weighing from 92 lb. to 100 lb. per yard were advisable. Some American companies had laid down rails weighing 130 lb. per yard for heavy traffic. In tunnels rails of from 104 lb. to 110 lb. per yard were advisable. The adoption of heavy rails permitted hard steels of high carbon content to be employed.

BOGIES (TRUCKS), AXLES AND SPRINGS OF LOCOMOTIVES.

When Section II assembled on April 20 under the presidency of Mr. George Gibbs, Electrical Engineer to the Long Island Railroad, N.Y., it first took up the consideration of the best arrangement of the bogies, axles and springs of locomotives, especially of locomotives for high speeds and with long wheelbases, to facilitate running round curves and to ensure proper stability. Mr. George Hughes of the Lancashire & Yorkshire Railway, presented a report on the subject embodying the experience of Great Britain and the English-speaking countries; M. E. Minsart, of the Belgian State Railways, reported concerning the experience of Belgium, Denmark, Sweden and Norway, and M. Bochet, of Paris, dealt with certain other countries. We give the following abstracts of these three reports.

In his report Mr. G. Hughes, of the Lancashire and Yorkshire Railway, said, many of the deductions as to trend of practice were rather indefinite, and the tables accompanying the report should be studied for details. Some deductions were obvious. Among these was the fact that the swing link type of bogie was peculiarly American, and the side play allowed by it was greater than in the traversing sliding type which was generally the standard in the British Isles. The load on the bogie was usually 20 to 24 tons in modern engines. In Great Britain it was usual, with two exceptions, to put the pivot in the geometrical centre of the wheel base. No reference in the replies received was made to any application of the Cartazzi control. In America laminated springs were the rule for bogies and other wheels. On British railways laminated or helical springs were used on bogies, and laminated for coupled wheels, though some roads employed helical springs for the main drivers. Laminated springs damped down oscillation. The average flexibility of bogie springs was 0·249 in. per ton, and for driving springs 0·238 in. per ton. Equalising was always provided in American practice but seldom on British engines. The height of the centre of gravity of the sprung weight ranged from 4 ft. 9 in. to 7 ft. 3 in. In American practice outside horizontal cylinders were always used. In two-wheeled trucks the distance from the axle centre to the radius bar pivot was about 6 ft. On American two-wheeled trucks helical springs were used. Generally, it was the practice to balance all revolving weights and two-thirds or three-quarters of the reciprocating parts. Various formulae were in use for super-elevation on curves but gave much the same results. From an engineering point of view the ratio of track to bogie wheel base should be about 1 : 1·5, or a base of about 6 ft. 7½ in. for standard gauge track.

Dealing with some of these points in greater detail, Mr. Hughes pointed out that the duty imposed on the bogie in large modern engines, of guiding the engine round curves, was altogether out of proportion to its capacity, so that some of this work fell to the leading coupled wheels, with the result that the wear of the flanges of the latter was increased. This had led to the design of the lateral motion bolster carried on inverted heart-shaped rockers. The use of this type was said to result in much less wear on the front coupled wheels, and a less jerky motion round curves. The four-wheel bogie was practically universal for high-speed passenger work, but for freight work the two-wheeled truck was used. In the Adams bogie, used largely in the British Isles, the movement of the centre was in an horizontal plane only and spring controlled. On the Lancashire and Yorkshire 4-4-2 type engines, the swing link type had been used, but rolling proved excessive and the Adams pattern was substituted. On the Belgian State system the Flamme bogie was used. In this the bogie bolster was of the swing link type, but the cup was spherical, and a spherical centre casting fitted into it, thus giving the bogie universal movement and the bolster transverse motion. This bogie was braked, but generally bogies were not braked, only five systems out of 52 reporting the use of brakes on bogies. On the Lancashire and Yorkshire, brakes had been fitted to the bogies of 4-6-0 engines but had been unpopular, and had been discontinued.

On the subject of frames, Mr. Hughes thought that if the additional weight put into stiffening plate frames was put into cross bracing a much stronger frame would result. The knowledge we had of the working stresses of such frames was so incomplete that the best that could be done was to allow a margin. The bar frame on the whole was lighter than the plate frame. Stiffening plates were used attached to the boiler; these caused grooving. With the bar frame the centre line of the frame was coincident with the bearings, springs, &c., and no torsional stresses resulted as in the plate frame. Spring failures ran from 10 to 15 per cent. per annum. Unevenness of the track resulted frequently in the static load on a spring being exceeded by 100 per cent. For this reason equalising was an advantage, but it was difficult to attach the required fulcrum brackets satisfactorily to an unstiffened plate frame. British roads did not really demand the practice to the same degree. If cross equalising was adopted the machine can be arranged for three point suspension. In the 4-6-0 class of Lancashire and Yorkshire engines care had been taken to get the weights on the springs naturally. Screw adjustments were not required after erection. The position of the boiler was fixed accordingly and the final weights came out very near to the estimate. After discussing points relating to balancing, adhesion, wear of rails, height of centre of gravity, etc., Mr. Hughes said it was customary to give rather too much super-elevation than too little. Curve tables should give the proper elevation for a given speed and also the maximum safe speed for the highest centre of gravity in use. Transition curves should be used for all curves of 87 chains or less. English practice allowed a movement of 2 in. for the boxes in the horns; other countries allowed greater play.

As regards tyres, when turning up, all were, in English practice, turned down to the diameter of the worst worn pair. That involved a good deal of waste. In America, tyres were changed about from the wheels where the wear was greatest to where it was least. Flange lubrication had been adopted in some cases, and had given an increase of tyre life from three to 20 months, the general extension being about 75–80 per cent.

M. E. Minsart's report was a lengthy one, copiously illustrated, mainly by Belgium State practice. He classified bogies in several groups. The first three fundamental groups consisted (1) of bogies fitted with a centre pivot, with spherical bearings; (2) bogies with spherical lateral bearings, allowing a certain amount of rocking motion in the longitudinal direction; (3) bogies with flat central or side bearings, in which the bogie frames participated in all engine oscillations, both longitudinal and transverse. In the first kind, rolling of the engine did not bring the bogie springs into play, and the righting effect was somewhat reduced as a result. Such bogies were not fitted with equalisers. In bogies with flat bearings the bogie springs assisted in the righting effect during rolling. If it was desired to obtain a constant distribution of weight with these bogies, equalisers must be fitted. Bogies might again be distinguished by whether they were kept central (*a*) by springs, or (*b*) by gravity, or (*c*) bogies which had an initial centreing action, and (*d*) bogies in which this was not exerted. Both (*a*) and (*b*) could be arranged to fall into either classes (*c*) and (*d*). The triangular link (three-point hanger) provided initial centreing effort. The Belgian State Railways employed bogies with spherical pivot and centre suspended by links. In trailing bogies fitted to tank engines centreing by inclined links was also secured, but the arrangement introduced equalising between the load on the bogie and the couple wheels. The centre consisted of a long pin, and carried no load. It worked in a hole in a bolster swung from the bogie transom casting, and the load was taken on two fulcrums mounted on the bolster, on which equaliser beams rested, one end of the latter being attached to the engine frame, and the other to the coupled wheel rigging. Bogies with link centreing appeared to be preferable to those with spring control. The three-point hanger type relieved the leading coupled wheels, but the bogie springs should be equalised. Some roads used two bogie springs, arranged between the axles; others four springs over the boxes, with compensating beams.

Most bogies were fitted with brakes with rigging completely independent of that for the engine. The central pivot was usually placed midway between the axles, but with braked bogies it was an advantage to have it slightly behind the actual centre. Bogie springs were usually laminated. Pony trucks were centred by springs or gravity; the latter was the simpler. In one class on the Belgian State Railways the pony truck was a modified form of the Zara arrangement, the truck being pivotted on a centre spherical bearing, while the frame acted as a compensating lever, coupled with the springs of the nearest coupled wheels, whose boxes were held by the main frames. Radial boxes, or those with lateral play, were centred by springs or by inclined planes under the bearing springs. The centreing of a back axle was not so valuable as that of the front. In the case of coupled wheels with side play, the crank pins might be made spherical. On a recent class on the Belgian State Railways the boxes were hung on trunnions fixed to plates carried in turn by sockets centred 3 1/8 in. higher. The sockets were in shoes, which worked in the horn, and to which was applied the spring load. The effect was that the axle and box was allowed the side movement permitted by a pendulum link 3 1/8 in. long. The brake hangers were arranged with vertical articulation to accommodate the blocks to this side movement. As regards balancing, a variation of rail pressure of 15 per cent. was allowed with 2-cylinder engines. In Norway and Belgium nickel steel was used for crank axles. Converging buffers between engine and tender were not much employed.

Equalising was generally practised. In most engines the axles were arranged in two groups, in which the springs were equalised, thus providing four-point suspension. In a certain number of engines transverse compensation was introduced in such a way as to result in three-point suspension. Compensation was an advantage on hilly and sinuous roads. With regard to play allowed between the flanges and rails, the smaller this was, in moderation, the better the running, and the less the wear. In some cases the flanges of middle coupled wheels were reduced in thickness. Generally, laminated springs had an advantage, due to their damping action. For moderate speeds, three-point suspension was suitable, but for high speeds the springs should be arranged so as to reduce rolling. Longitudinal oscillation was best counteracted by long wheel base, effective control of side movement, and by small play between the flanges and rails, as well as by reducing the weights of the reciprocating parts.

M. Bochet, of the Ministry of Public Works, France, was responsible for a long report on the same subject dealing with non-English speaking countries except those covered by M. Minsart. M. Bochet found that there was such divergence of detail that his report was more descriptive of types than a discussion of principles. There were few outstanding features to bring into prominence. The question of an initial centreing force showed considerable difference of opinion, and no marked preference for or against this was to be discovered. It was possible a simple spring control might be combined with vertical centre hangers or links, with advantage. In general the arrangements of pony trucks might be simplified with some advantage. If trucks or bogies were fitted at both ends of an engine care should be taken not to give too much play. Four-wheel bogies could be classed in two groups: those having a centre bearing and pivot combined, and those having a centre pivot with side bearings. In the latter the load was taken by the side bearings and the pivot merely did the guiding, centreing being controlled by springs acting on a sliding centre casting. In the swing-link type the centre both carried the load and acted as the pivot. Initial centreing was secured with the three-point type of hanger. The Paris-Lyons-Mediterranean bogie used a spherical centre mounted on inclined planes on the Cartazzi system. Laminated springs are commonly used on bogies, often placed between the axles with equalising beams carried over the boxes. The French Northern Railway adopted longitudinal equalising beams from which were hung on either side two short inverted laminated springs.

The Zara type of truck, in which the leading pair of wheels was carried in a truck pivoted to a

frame carrying the leading coupled wheels, was used by some railways with varying success. The Swiss railways had used it, but had not fitted it on recent engines. The Paris-Lyons-Mediterranean had used it, but was not extending its use. The Orleans Railway considered it advantageous on lines with 7½ to 10 chain curves, but it was complicated and therefore only adopted for mountain roads. The Italian State truck now used was not of the true Zara type, as the coupled wheels were carried in boxes in the main frame and were allowed only a small amount of movement. The bogie centre was of the swing link type with spring control. The leading and leading coupled wheels were equalised by means of the truck frame, while short laminated springs were also placed over the leading boxes. The Italian railways considered this truck equal to the four-wheel truck. The two-wheel or pony truck proper was in general use in various designs. In some, side bearings and a spring-controlled pivot were used, the load being transmitted through sliding shoes and pillars to springs on the main frames. In other cases springs over the bogies were fitted to the truck frame. On the Northern Railway of Spain, centreing was arranged by rollers in brackets fixed to the main frame working on concave roller paths on the truck frame. The inverted heart-shaped rocker (Woodard) truck was being used by the Orleans Company. Several railways allowed side play to the coupled wheels and applied balls and sockets to the rods. Others made the flanges of the middle coupled wheels thinner, and considered this the cheaper and most effective method of getting over the difficulty of a long rigid base.

Laminated springs were most commonly used. Equalising was not universal, and one important road, having tried blocking the equalisers and obtained better results than with them free, had abandoned them. This, however, was regarded by others as a decision arrived at on inadequate investigation, and on the whole the opinion appeared to be that they are advantageous. A number of railways used the Roy coupling between engine and tender. This was a screw coupling with safety links on either side. On the engine were two solid buffer faces struck to a radius in plan. On the tender were two adjustable buffers whose faces set hard against the engine radial faces. No spring was interposed between the engine and tender. The paper was accompanied by numerous tables, and also by specifications for spring steel, &c.

In presenting to the meeting a summary of the three reports Mr. Hughes exhibited some photographs showing the method of determining experimentally the centre of gravity of a 60-ton locomotive by suspending it from different points. The height of the centre of gravity was thus found to be 4 ft. 11⅞ in., which compares well with the height of 4 ft. 10 in. predicted by calculation. The question of brakes on bogie-wheels was raised by Sir Henry Fowler who said that bogie-wheel brakes on the Midland Railway had proved satisfactory, and asked whether other delegates would give their experience of such brakes. It appeared that everybody who had tried them thought them satisfactory, Mr. Collett of the Great Western recommending them, Mr. Weiss of the Swiss Federal Railways saying that in Switzerland bogie-brakes were in use on about 200 locomotives, steam and electric, and were standard practice for all speeds over 75 km. per hour, while M. Bochet expressing the opinion that there was no danger in such brakes so long as the braked weight were kept within proper bounds. The design of bogies also came under discussion. M. Bochet compared the two methods of supporting the engine on the bogie, referring to them respectively as the Alsatian and the American system, and pointing out that the former resulted in a very steady engine under all circumstances, while the latter gave a great flexibility when entering a curve. M. Minsart remarked that on the recent four-cylinder compounds on the Belgian State railways, bogies with a central spherical pivot carried on a centre-plate suspended by the links had been completely satisfactory. Mr. Gresley stated that the Great Northern Railway now used a similar design, having abandoned the central flat bearing in favour of a spherical one. Mr. Gresley also used pony trucks with a double set of links, to give an equal distribution of weight on the two wheels. He further informed the meeting that by the use of chrome nickel steel he had been able to reduce the weight of the connecting and coupling rods by one-third. Hollow piston rods had also been introduced for the sake of lightening the reciprocating parts.

The conclusions which the Section arrived at were as follows: It is generally possible to construct modern powerful locomotives, having long wheel-bases, which shall be capable of taking curves of small radius without employing articulated frames. To facilitate the passage of such locomotives round curves, bogies or Bissel trucks are used for front or rear axles. The bogie has become practically standard practice for powerful high-speed locomotives. When the rear-axle is a coupled axle side-play is sometimes given to it, but the more usual practice is to thin the tyres of the intermediate axles. Bissel bogies were not sufficiently widely used to enable definite conclusions to be drawn concerning them. Some simplification of their design might often be adopted with advantage, and the length of the radius bar should be so proportioned that the axles remain normal to the curvature of the track. The same point should be kept in view when radial axles are used. Opinions differed concerning the best way of supporting the weight of the locomotive, and as to the best method of centreing it, so that no definite statement could be made. It might be stated, however, that devices which give the front axles lateral freedom about their central position, are advisable for service on light track with many curves. It was not the general practice to give a great deal of freedom both to the front bogie and to the rear carrying axle as well. Laminated springs were better than coil springs for the drivers and coupled wheels, on account of the effect of the friction between the leaves damping out oscillations. No new facts had been brought to light concerning compensating levers, so that the conclusions arrived at by the 1900 Congress still held good. When calculating the weights used to balance the reciprocating parts it was essential to make sure that the vertical forces introduced were not of sufficient magnitude to cause too great stresses in the rails.

Carriages and Wagons for Light Railways.

The first report to be dealt with by Section V was one by Sig. Carlo Gaviraghi, who reviewed generally the characteristics of light railways. This report loses something of its importance from the British point of view, by reason of the fact that although the author has considered the light railways of eight countries, those of India, Ireland and, indeed, of every part of the British Empire, are not taken into account.

Sig. Carlo Gaviraghi, who is engineer and manager of the Valtellina Railway, presented in his report particulars of stock on 22 narrow-gauge lines in Italy, France, Spain, Norway, Belgium, &c. In his conclusions the author expressed the view that standardisation of such systems was highly desirable. The lines varied as regards gauge by small amounts which could not be necessary. Passenger stock tended to approximate in form to that on normal lines. Heavy bogie coaches were now common for new stock. Comfort had been improved; electric lighting was employed on modern stock and steam heating. In freight wagons the tendency was also towards the bogie vehicle, and from the old 6-ton four-wheeled wagon the modern bogie stock had increased to 15 tons capacity. Four-wheeled vehicles, however, still formed the bulk of the stock. In large systems provision might be necessary for transporting normal gauge cars (especially tank cars) over the narrow-gauge lines. This was often accomplished by means of special trucks or transporter cars on which the others were temporarily mounted. A speed of 12 m.p.h. could be adopted with these vehicles.

Some railways had adopted a system involving a change of the distance between journal centres, using the same axles. Most narrow-gauge lines worked with mixed trains, but on some, where traffic warranted it, separate services were used. Narrow gauge should not be adopted in any system likely to form ultimately a useful link in other systems of communication. The investigation deciding the adoption of narrow-gauge should be as careful and comprehensive as would be undertaken for normal lines. Reconstruction to normal gauge was costly and inconvenient and should, if possible, be avoided by limiting the use of narrow gauge. Gauges should be as limited as possible in number, and rolling-stock standardised so that reduced expenditure might be incurred in purchasing and upkeep.

During the discussion, Sig. Biraghi made the point that the majority of light railways were less than 100 km. in length, and the companies owning them were debarred by that fact from being members of the International Association. He thought that many of these little railways might be able to furnish information which would be useful to the executives of the longer lines.

The rest of the discussion in this section turned principally on the question of standardisation. Everybody seemed in agreement that standardisation was desirable, but the plea of M. Forges Davanzati that any resolutions on the subject should be so worded as not to embarrass lines already in operation, shows the difficulties of the subject. It should also be remembered that most light railways are physically separated and distinct, so that uniformity of gauge or equipment is much less urgent than it would be in cases where through traffic has to be handled.

The final result of the discussion was the passing of two resolutions. The first of these resolutions was to the effect that standardisation of equipment (*unité technique*) of light railways is desirable and should be provided for by law in all countries in the case of new lines, the necessary legislation being promoted by the railway associations concerned. The second resolution, which seems somewhat superfluous in view of the first, was that the railway associations would benefit by adopting uniform standards for light railways, and by investigating types of rolling stock and locomotives (including electric equipment) which would be the most suitable for average working conditions. These investigations should be carried out in conjunction with the manufacturers concerned, with a view to facilitating mass production. A third resolution, which related to the desirability of making provision for carrying wagons of normal size when laying out new narrow-gauge lines, failed to receive the endorsement of the meeting.

(To be continued.)

Shipping at the Port of Danzig in 1921.—During the past year navigation took a considerable rise in Danzig over the preceding year, and as regards the burden the figures of 1921 were indeed higher than in 1913, although the number of ships was smaller. In the number of ships entering and leaving the port of Danzig, Germany still ranked first. But as regards tonnage, Denmark headed the list, the 195 ships under Danish flag totalling 318,079 register tons. Germany came next with 1,967 small ships aggregating 268,097 tons; then England with 210 ships of 254,215 tons, and the United States, with 66 large ships of 229,594 tons. Big ships came also from Belgium, the 10 ships aggregating 47,856 tons. The 255 ships flying the Danzig flag were small, of 59,343 tons altogether. Of the craft of other nationalities only the Netherlands exceeded 90,000 tons with their 75 ships.

Attendances at German Technical High Schools.—During the past winter, 1921–22, the attendances at the 13 Technical High Schools of Germany—including Danzig, which has to stand apart—have still continued to increase. The total students' number of 1913–14 was 16,989, comprising immatriculated students, hearers and guests; in 1921–22 the total was 31,194, and the greatest increase was noticeable in the faculties of engineering and electrical engineering, which were attended by 4,304 students (of all classes) in 1913–14 and by 13,400 in last winter. The courses on engineering and electrotechnics were in 1913–14 attended by 36·7 per cent. of all the students, and last winter by 53·4 per cent. There were decreases last winter, however, in architecture, building construction and shipbuilding, whilst mining, chemistry and metallurgy, and forest culture and agriculture attracted more students. That Munich shows the maximum attendance with 5,154 students—Berlin comes next with 4,820—is partly due to the fact that it is the only Technical High School which has also departments for forest culture and agriculture; 571 students were enrolled in these two departments. The numbers of attendants from abroad increased again last winter in most places, from 6 per cent. to 20·7 per cent. in Danzig, and from 14·3 per cent. to 18·9 per cent. in Berlin, but it went down to 2·3 per cent. in Munich.

COASTAL MOTOR BOAT FOR THE FRENCH NAVY.

CONSTRUCTED BY MESSRS. J. I. THORNYCROFT AND CO., LIMITED, ENGINEERS, SOUTHAMPTON.

Fig. 1.

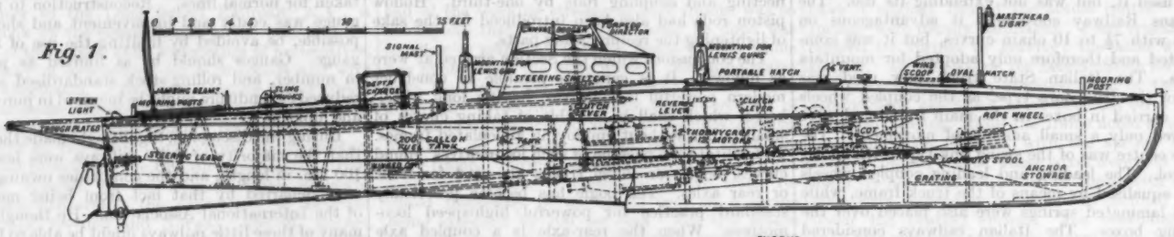
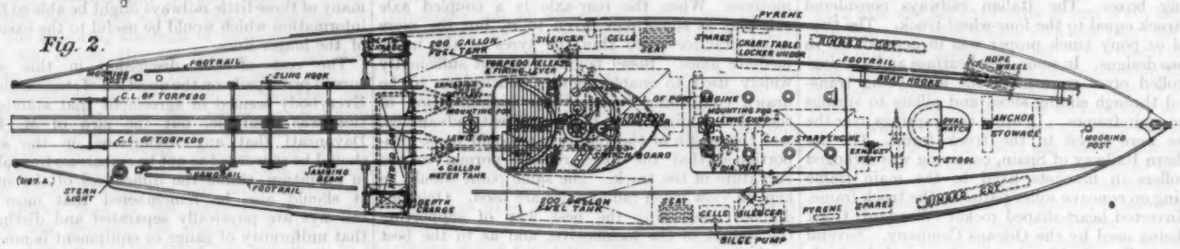


Fig. 2.



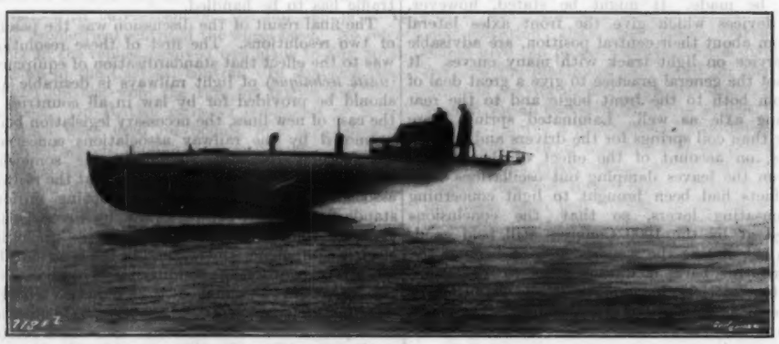
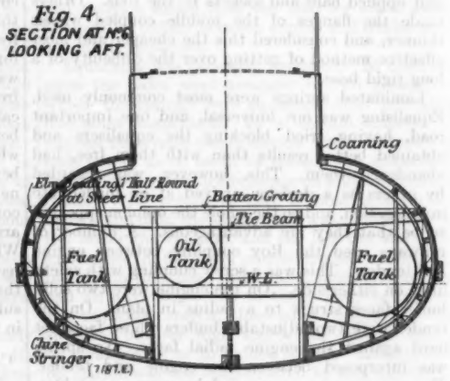


FIG. 3.

Fig. 4. SECTION AT M.C. LOOKING AFT.



WHATEVER may be the ultimate decision as to the employment of light craft in naval warfare of the future, there can be little doubt that the class of small high-speed torpedo vessels propelled by internal-combustion engines, and known as coastal motor boats (or more familiarly as C.M.Bs.), will play an even more important part than they did in the last war. The form of hull employed in these vessels, which are of the skimming type, was developed by model experiments carried out by Sir John I. Thornycroft over a period of ten years or so prior to the war, the object being to produce a form having a very low resistance combined with good sea-going qualities. Tank experiments alone were not sufficient to determine the best proportions and form, and actual boats which were built and tried at sea by Sir John's son, Mr. Tom Thornycroft, played an important part in the developments. The boats of this class constructed before the war, however, were only employed for racing and experimental purposes, carrying not more than two or three men, and just sufficient fuel for the completion of a race. Considerable modification was therefore necessary to render them suitable for carrying one or two torpedoes, each weighing about 15 cwt., as well as the fuel supply necessary to give a useful radius of action, the crew of three or four men required to work the boat under war conditions, and the discharging gear for the torpedoes. However, at the period of the war when Admiral Sir Henry Jackson was First Sea Lord, it was decided that motor torpedo boats should be built, and Messrs. John I. Thornycroft and Co., Ltd., whose London address is now Thornycroft House, Smith Square, S.W. 1, were given instructions to build, as quickly as possible, twelve experimental boats of the special form of hull to which reference has been made. Further experiments were carried out, and the designs prepared for 40 ft. and 55 ft. boats, of which a large number was eventually built by Messrs. Thornycroft themselves and several other firms acting as their sub-contractors from 1915 to 1918.

A full account of the exploits of these vessels would form extremely interesting reading, but the utmost secrecy was naturally observed regarding their construction and employment during the war, so that, for a considerable period, the general public was quite unaware of their existence. Very little has been published on the subject since the conclusion of hostilities, but it is now known that the vessels were first employed in the winter 1916–17 at Dunkirk, from which base they were frequently in action with German patrol boats and destroyers. For work in the North Sea they were based at Harwich, and armed with depth charges, as well as with torpedoes, were effectively employed in countering the submarine menace. They were also used for laying mines in positions which were inaccessible to ordinary mine-laying craft. More striking, however, was their work in connection with the blocking actions at Zeebrugge and Ostend in 1918, and, after the armistice, in the attack on Kronstadt. It will be remembered that the Russian cruiser Oleg was first torpedoed by a coastal motor boat outside Kronstad Harbour and that afterwards several Russian vessels were destroyed in the harbour itself in an action that was unique in naval history.

That the possibilities of coastal motor boats are now being considered by other naval powers may be gathered from the fact that Messrs. Thornycroft have received orders for them from the French, American, Japanese, and other Governments, so that the particulars of their design and construction we are now able to publish should be of considerable interest. The boats built for the French, American, and Japanese navies are practically identical with those employed by H.M. Navy during the war. In all, four sizes have been developed and built, two being 40 ft. and 45 ft. in length respectively, and each carrying a single torpedo; one 55 ft. in length carrying two torpedoes, and one 70 ft. in length carrying three or more torpedoes. The majority of these built have been of the 55 ft. type, and it is a boat of this size, supplied to the French Government, that we are about to describe in detail. This boat is designed to carry two 18-in. torpedoes and two depth charges. Mountings for two Lewis guns are also provided, as shown in the general arrangement drawings reproduced in Figs. 1 and 2, on this page, mainly for the purpose of resisting aerial attack. The other main dimensions of the hull are: Beam, 11 ft. and draught, 3 ft. 3 in., the latter figure, of course, being taken when the boat is at rest. When travelling at full speed, the whole of forward portion of the hull is above the water level, the boat then being supported by the dynamic lift supplied by the inclined surfaces formed by the step amidships and the extreme after end of the hull. The draught in this condition is only a few inches, as will be gathered from Fig. 3, which shows the boat travelling at 41·6 knots—the mean speed attained on trials in the fully-loaded condition.

The outline of the hull is shown in Figs. 1 and 2, and the cross-sections given in Figs. 4 and 7 will help to make its construction clear. The hull is carvel built with two skins of selected mahogany, timbers of American elm and stringers of Oregon pine; copper fastenings are employed throughout. An oval hatch, fitted with a wind scoop for ventilation purposes, is provided forward, as shown in Figs. 1 and 2, and aft of this is a large rectangular hatch through which the engines can be removed. The cover of the engine hatch is provided with six circular port lights, 5½ in. in diameter, of aluminium alloy, and glazed with Triplex glass. Amidships is the steering shelter formed by a vertical coaming, as shown in Fig. 4, and fitted with a canvas "dodger" for protecting the helmsman from wind and spray. The steering wheel is of the motor-car type operating twin rudders through flexible steel cables, with a duplicate wheel on the roof of the steering shelter.

The arrangements for carrying and releasing the torpedoes are clearly shown in Figs. 5 to 8, on page 549. From Fig. 7 it will be seen that two troughs, formed of mahogany boards, are provided in the after portion of the boat. Along both sides of the troughs are oak runners faced with strips of manganese bronze, and the torpedoes, which lie in the troughs, are fitted with angle brackets which rest on the runners as shown in Fig. 8. The troughs are supported inside the hull by mahogany struts, the arrangement of which is best shown in Fig. 5, and the runners, which extend over the stern, are carried by steel plates as indicated in the

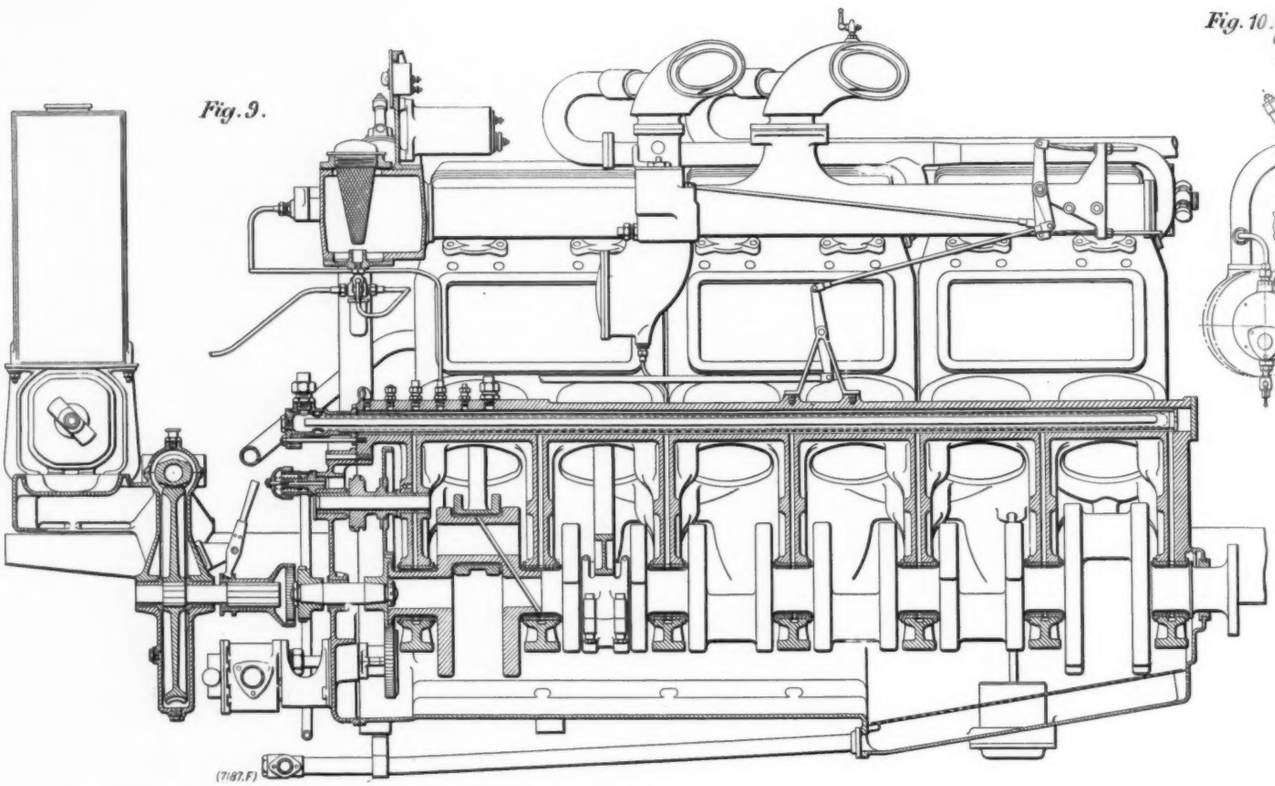
375 B.H.P. 12-CYLINDER PETROL ENGINE AND ST

CONSTRUCTED BY MESSRS. J. I. THORNYCROFT AND

(For Description, see

Fig. 10. VERTICAL SECTION
CAMSHAFT DRIVE &
LOOKING FROM FRO

Fig. 9.



(7187.F)

Fig. 12. PART PLAN OF CAMSHAFT HOUSING WITH COVERS REMOVED. DITTO WITH CAPS AND ROCKERS PEMOVED.

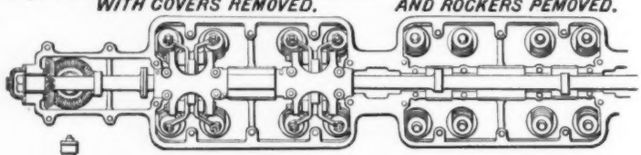


Fig. 11. PART VERTICAL SECTION THROUGH CYLINDERS.

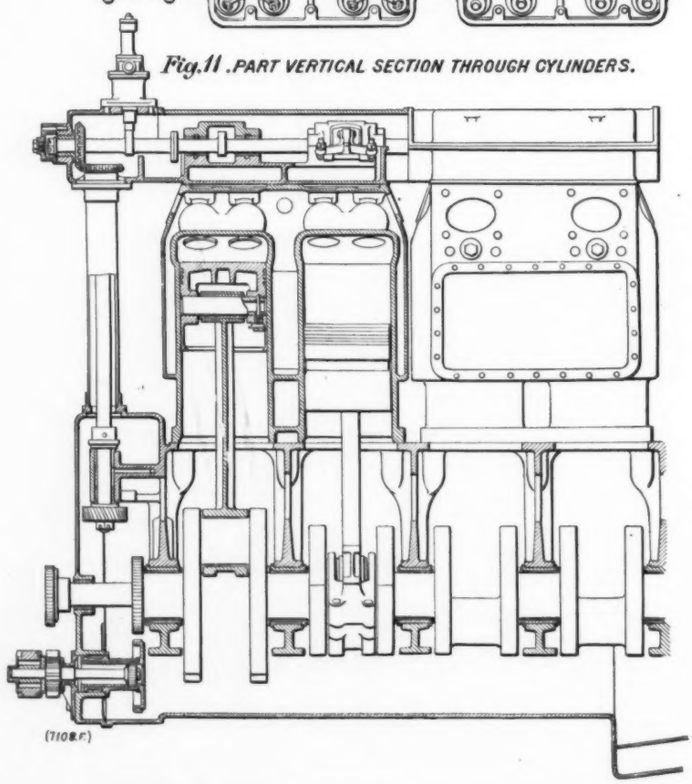


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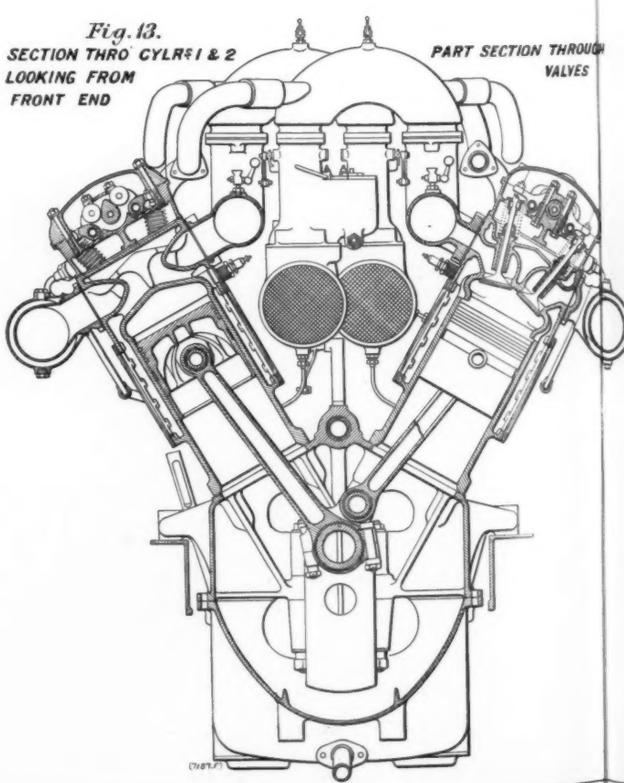
Fig. 13.
SECTION THRO' CYLRS 1 & 2 LOOKING FROM FRONT END

PART SECTION THROUGH VALVES



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ND STARTING GEAR FOR COASTAL MOTOR BOAT.

YCROFT AND CO., LIMITED, ENGINEERS, SOUTHAMPTON.

(Description, see Page 548.)

ERTICAL SECTION THROUGH
IMSHAFT DRIVE & FRONT COVER
OOKING FROM FRONT END.

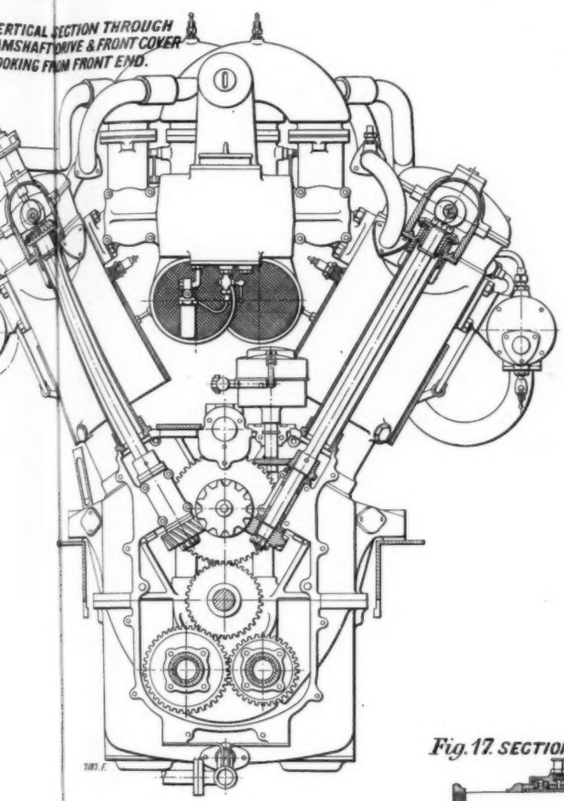


Fig. 15.

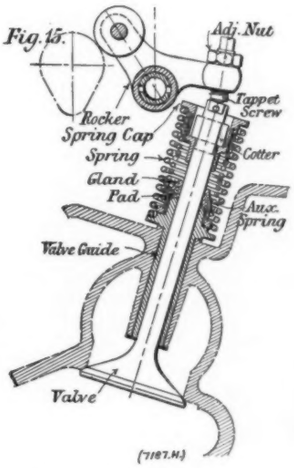


Fig. 16.

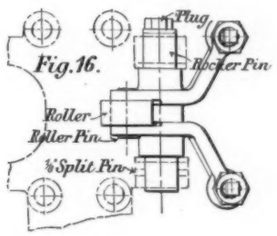


Fig. 17. SECTION THROUGH MECHANICAL BARRING GEAR.

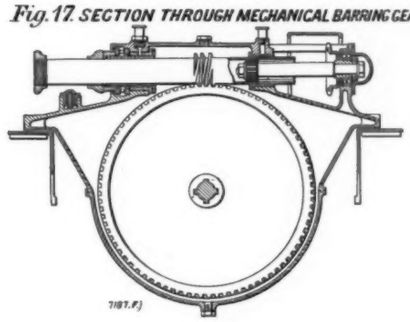
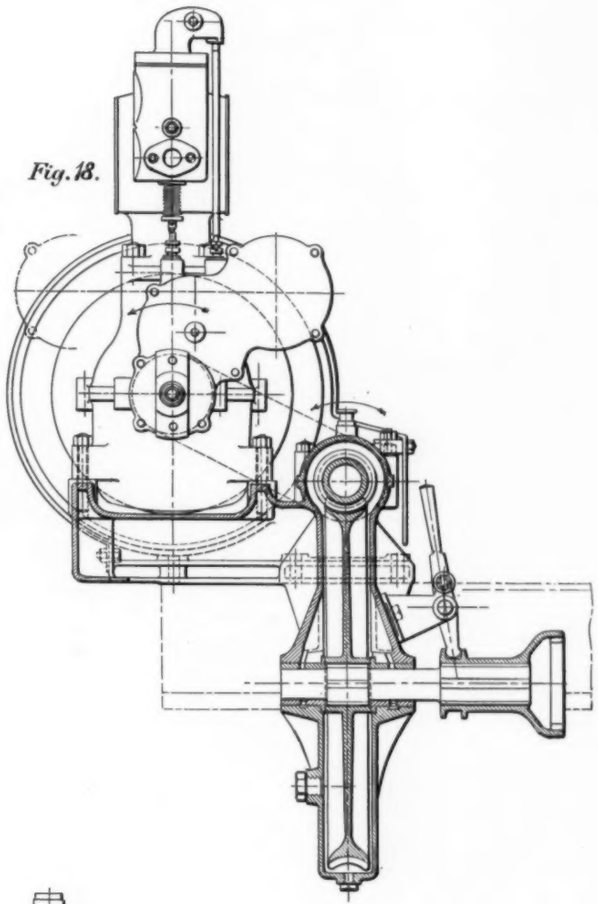


Fig. 18.



N THROUGH
VALVES

HALF-SECTION
BETWEEN CYLRS 9&11.
LOOKING FROM FRONT END.

Fig. 14.

HALF-SECTION
BETWEEN CYLRS 10&12.

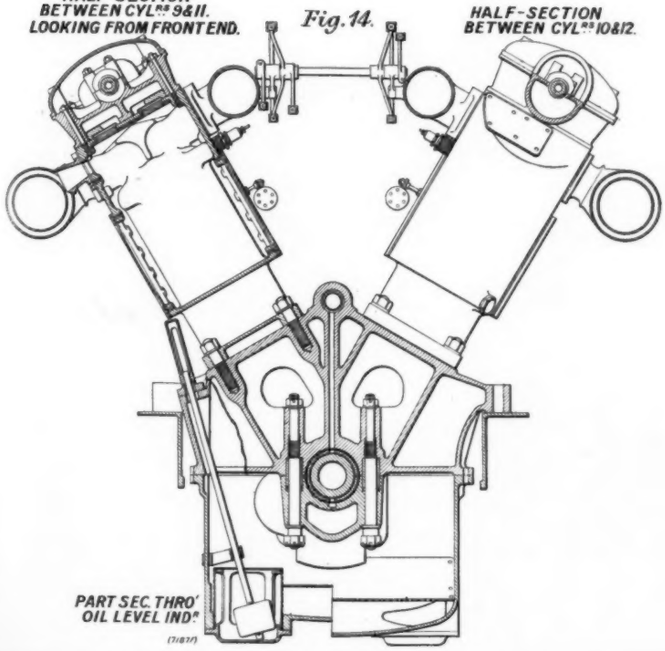
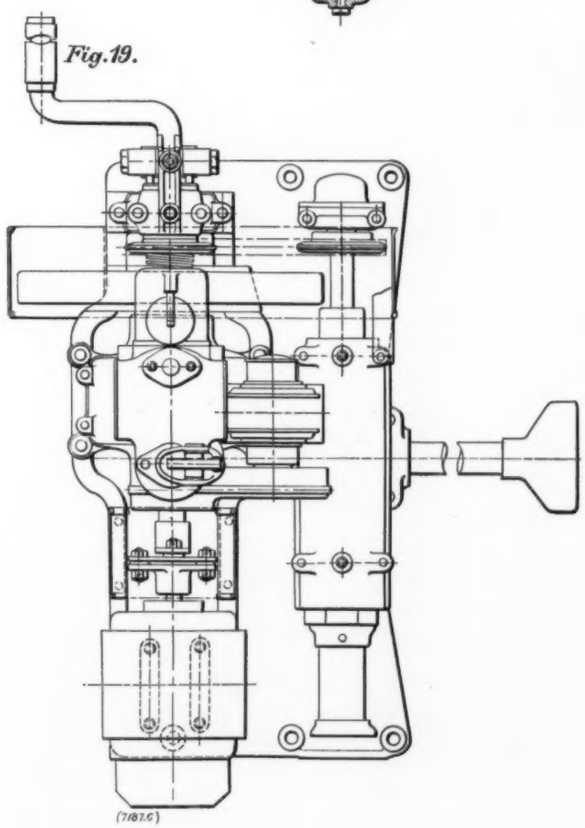


Fig. 19.



DETAILS OF COASTAL MOTOR BOAT FOR THE FRENCH NAVY.

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Fig. 5.

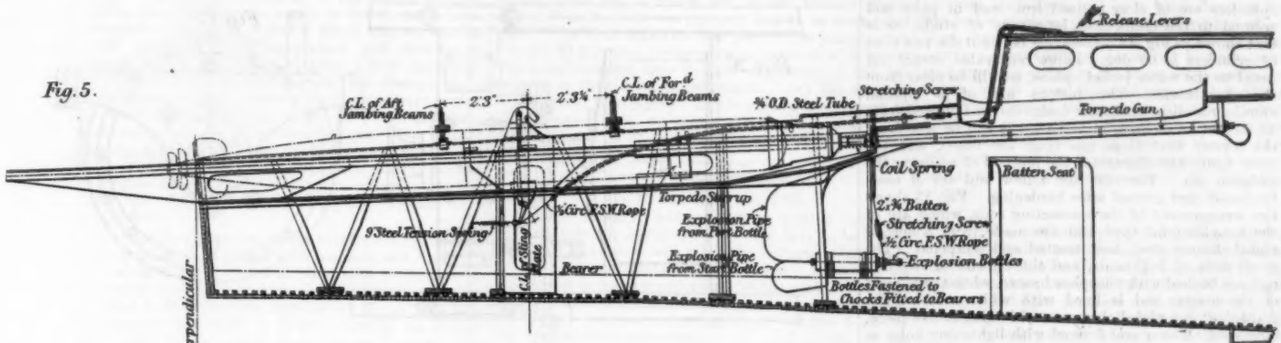


Fig. 6.

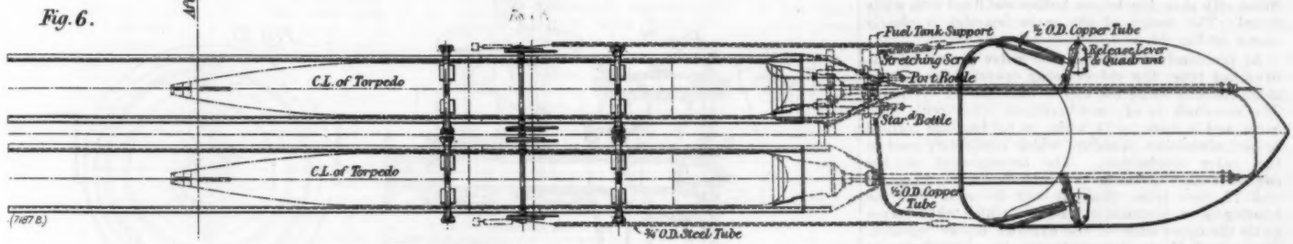


Fig. 7. SECTION THROUGH SLING PLATES.

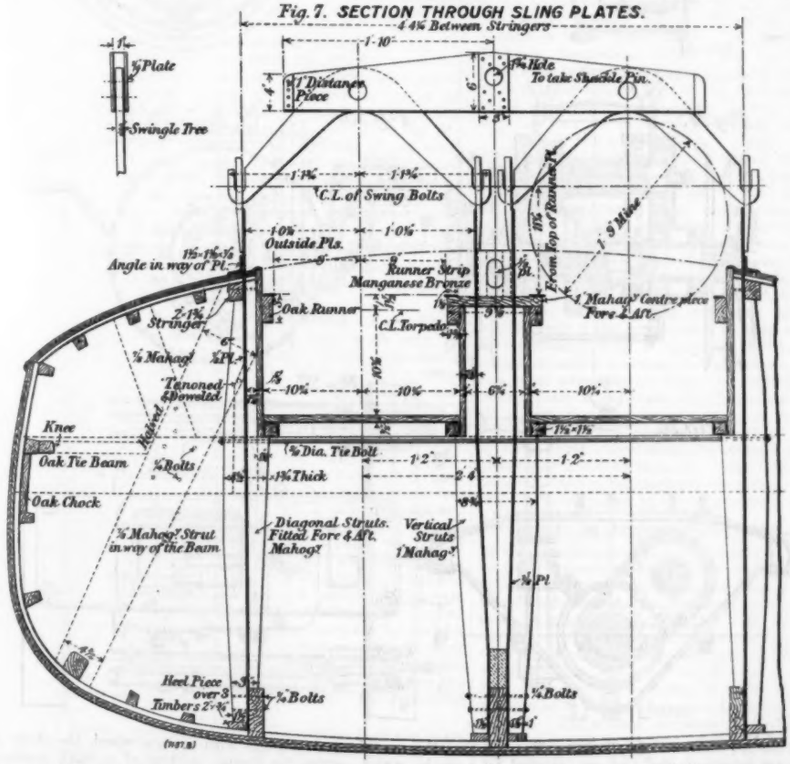
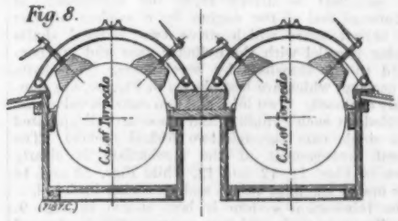


Fig. 8.



same illustration. Each torpedo is normally secured by a pair of jambing beams fitted with screw chocks, which clamp it firmly in position. The jambing beams are located as shown in Figs. 5 and 6, and their design will be clear from an inspection of Fig. 8.

Before describing the torpedo-releasing gear it should be explained that one, or both, of the torpedoes is discharged over the stern of the boat, while the latter is travelling at full speed in the direction of the objective. As soon as the torpedo is launched, the course of the boat is altered so that it clears the objective, and the torpedo, of course, continues to travel in the original direction. It will be understood that there would be no danger of the torpedo striking the boat itself, even if the course of the latter were not changed, since the torpedo sinks to a depth of about 6 ft., and would therefore easily pass under the hull. Moreover, the speed of the torpedo does not greatly exceed that of the boat, so that a considerable time would be required for the former to catch up. To assist in aiming the torpedo, the director gear indicated in Figs. 1 and 2 is provided on the steering shelter. The gear consists of an arm carrying a pointer and moving over a graduated quadrant. When the objective is a stationary one, the arm is set in the middle, or zero, position of the quadrant and the boat is steered so as to bring the pointer, the stem of the boat and the objective in line; the torpedo is then discharged. The procedure is exactly the same when aiming at a moving object, such as a warship, except that the arm of the director gear is set to one side or the other of the mid-position in accordance with the estimated speed of the objective.

For launching the torpedoes the gear illustrated in Figs. 5 and 6 is employed. The gear, which is fitted in duplicate, comprises a steel bottle connected by copper piping to a torpedo "gun." The latter consists of a solid-drawn steel tube, 2⅞ in. in diameter and 8 ft. long, fitted with a piston and piston rod, and on the outer end of the latter is provided a steel cap in which the nose of the torpedo rests as indicated in Figs. 5 and 6. When a torpedo is to be launched, the clamping screws are first slackened off, and the officer in charge pulls one of the release levers mounted on both sides of the steering position. This fires a cordite cartridge in the corresponding bottle, and the gas pressure generated, being communicated to the gun, forces the piston along the tube, thus driving the torpedo down along the runners and into the water; the propelling mechanism of the torpedo is automatically started up during the movement.

When the boat is to be used for mine-laying, the mines are carried in the torpedo troughs, as indicated in Fig. 7, and this illustration also shows the sling plates provided for lifting the boat out of the water and carrying it on a larger vessel. The sling plates are fitted at the after end only, the forward end being supported by a wide canvas band.

The engines, of which two sets are fitted, were specially designed and constructed by Messrs. Thornycroft for the 45-ft. and 55-ft. coastal motor boats. They are illustrated in considerable detail on Plate XXIII, which accompanies this issue. From Figs. 9 and 10 on this plate it will be seen that the engines, which run on petrol, are of the twelve-cylinder "Y" type, with overhead valve mechanism, the carburettors and inlet manifolds being located between the rows of cylinders, while the exhaust manifolds run along outside the rows. The inlet and exhaust connections to the cylinders are best shown in the transverse sections given in Fig. 13. The cylinders are 5½ in. in diameter while the piston stroke is 7 in. and the engines each develop 375 b.h.p. when running at from 1,500 r.p.m. to 1,600 r.p.m. The petrol consumption is guaranteed

not to exceed 0·7 pint per brake horse-power per hour. The crank-case is an aluminium casting split longitudinally in the horizontal plane, and its design can be followed by examining the longitudinal and transverse sections given in Figs. 9, 10, 11, 13 and 14. The cylinders are of close-grained iron, cast in pairs and secured to the crank-case by means of studs, as is best shown in Fig. 14; the angle between the two rows of cylinders is 60 deg. Large removable covers are fitted to the water jacket spaces, as will be clear from the illustrations. The pistons are of a special aluminium alloy, and their design can be followed from an inspection of Figs. 11 and 13. It will be seen from the former that three gas rings are fitted, and the same figure also illustrates the method of securing the gudgeon pin. The pins are hollow and are of case-hardened steel ground after hardening. Fig. 13 shows the arrangement of the connecting rods, which are of the knuckle-joint type and are made from a special nickel-chrome steel, heat treated and tempered. The small ends of both rods, and the big-end of the link rod, are bushed with phosphor bronze, while the big end of the master rod is lined with white metal. The crankshaft is a nickel-chrome steel forging in one piece, machined all over and formed with lightening holes as shown in Fig. 9. It runs in seven main bearings fitted with phosphor-bronze bushes and lined with white metal. The design of the main bearings is clearly shown in Fig. 14.

As previously mentioned, the valve gear is of the overhead type, the valves being operated by a camshaft running along the top of each row of cylinders. The camshaft is of case-hardened steel with solid cams, and it runs in 14 white metal bearings formed in cast aluminium housings which completely enclose the valve mechanism. The arrangement of the camshaft and housings is best shown in Figs. 11 and 12, and from these it will be seen that the housing is a continuous casting, which thus serves to tie the upper ends of the cylinder blocks together. The camshaft is driven from the crankshaft at the forward end of the engine by a system of spur and helical gears which drive two inclined shafts running parallel with the cylinder axes and are connected to the camshaft by bevel gears. The shafts and gearing, which are best shown in Fig. 10, are completely enclosed. Two inlet and two exhaust valves are provided on each cylinder, and these are all operated by a single cam through two forked rockers. The general arrangement of the mechanism is clearly shown in Figs. 11, 12 and 13, while Figs. 15 and 16 show one of the inlet valves and its rocker in detail.

The lubrication system is best shown in Fig. 9. The oil supply tank, which is water-cooled, is situated at the forward end of the engine, and oil is drawn from this by the suction side of a duplex pump of the gear type driven by spur gearing from the crankshaft. The delivery side of the pump supplies the oil to a longitudinal passage in the upper part of the crank-case, fitted with a perforated metal strainer and a muslin filter. From the main passage, the oil flows through ducts formed in the webs of the crank-case to the main bearings and thence through pipes fitted in the crankshaft to the crank pins. The pistons and the small ends of the connecting rods are lubricated by oil thrown off from the crank pins. Oil is supplied to the timing gear bearings by holes in the crank-case in connection with the main longitudinal passage and external pipes connected to the latter conduct oil to the hollow camshaft for the lubrication of the cams, rocker bearings, &c. All the used oil ultimately drains back to a sump formed in the after end of the crank-case, and from this it is pumped back into the supply tank by a separate scavenge pump, which is also of the gear type. The oil pressure used is from 20 lb. to 25 lb. per square inch when the engine is hot and a relief valve is fitted to prevent this pressure from being exceeded. An oil level indicator of the float type, shown in Fig. 14, is provided to call attention to an accumulation of oil in the sump which might arise from faulty working of the scavenge pump.

The cooling water is circulated by a gear type pump driven from the crankshaft, and is passed through the cylinder jackets and exhaust manifolds in succession. The hot water is also passed through jackets on the bends of the induction pipes connecting the carburettors with the inlet manifolds for the purpose of heating the mixture and thus improving the vaporisation. The water connections to the induction pipe jackets are shown in Figs. 10 and 13. It should also be mentioned that each of the exhaust pipes leading the gases outboard is composed of two flexible copper tubes arranged concentrically one inside the other, water being circulated through the annular space between the two pipes. This arrangement helps materially in keeping down the temperature of the engine-room and also reduces the number of hot parts with which accidental contact may be made in the somewhat confined space round the engines. Two carburettors of the Zenith choke-diffuser type are fitted, one for each row of cylinders. The two throttle levers are interconnected and are operated by a single hand control lever. The ignition, which is effected by accumulators and coil, is operated by a separate control. Petrol is supplied to the float chambers from two 200-gallon tanks which are sufficient to give the boat a radius of action of about 250 sea miles. The air pressure for the fuel supply is obtained from a small pump operated by a cam on the engine camshaft, and shown in the top left-hand corners of both Figs. 10 and 11.

For starting up the starboard engine, the gear shown on the left-hand side of Fig. 9 and illustrated in greater detail in Figs. 17, 18 and 19, is provided. It comprises a small petrol engine developing about 2 b.h.p., and driving a worm shaft through a cone clutch and roller chain as indicated in Figs. 18 and 19. The worm on this shaft engages with a worm wheel, the shaft of which carries the female portion of a small positive clutch. This part can be slid along the splined worm-wheel shaft into engagement with a corresponding part on the crankshaft by means of a hand lever, as will be clear from an inspection of Fig. 9. The crank handle shown in Fig. 19 is used for starting the auxiliary engine and can also be employed for turning the main engine slowly by hand. If the auxiliary engine is running and the cone clutch is engaged, the main engine is rotated at about 12 r.p.m. until it fires. When this occurs, the worm shaft, which is hollow and is free to slide longitudinally in its bearings, is driven to the right in Fig. 17, and a collar on the left-hand end of the shaft engages with a spring catch shown in the illustration, and holds the worm out of engagement with the worm wheel; the shaft must be pulled back

DETAILS OF COASTAL MOTOR BOAT; FRENCH NAVY.

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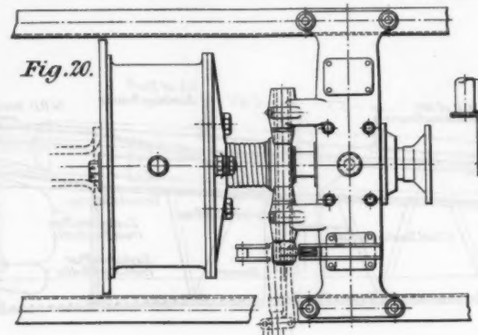
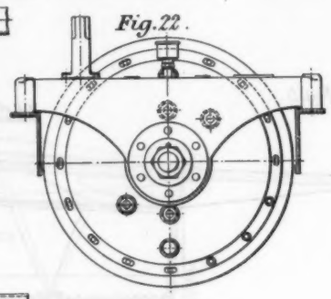
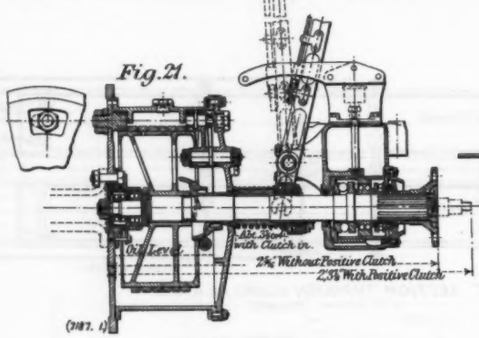
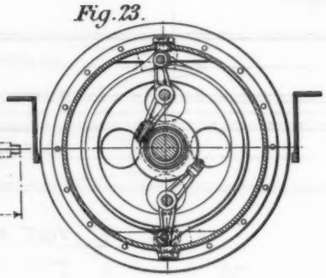
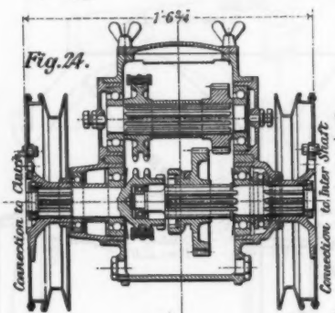
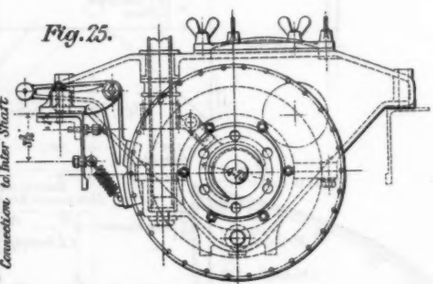


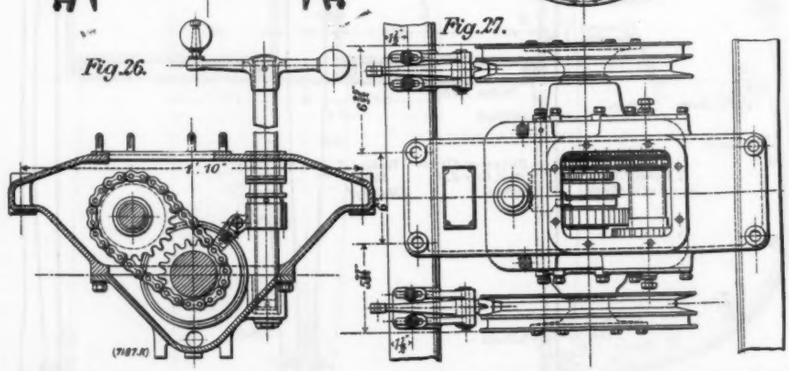












by hand to re-start the engine. In the event of the engine back-firing when starting up, the worm shaft would, of course, be driven in the opposite direction, *i.e.*, to the left in Fig. 17, and the effect of this would be to shear the pin by which the ball thrust collar taking the normal driving thrust on the shaft is secured. Another pin can, however, easily be fitted, and a fresh start made. The port engine is fitted with an electric starter operated by accumulators and similar in principle to the mechanical starter above described. The accumulators for this purpose are charged by a small electric generator driven by the auxiliary engine and shown at the bottom of Fig. 19; the generator also supplies current for lighting the boat. It is usually possible, however, to start up the port engine, when the boat is under way, by putting the clutch between the engine and propeller shaft into engagement, the engine then being turned round by the propeller drag until it fires.

The boat is manœuvred on the starboard engine only, this engine being provided with a clutch and reversing gear, while the port engine is fitted with a clutch only. The latter is of the coil type and its design and construction is illustrated in Figs. 20 to 23, on page 550. The engine crankshaft is bolted directly on to the front plate of the clutch body, at the forward end, and the ends of the two coil springs are secured to this plate by anchor bolts. The other ends of the coils are attached to the shorter arms of two bell-crank levers, most clearly shown in Fig. 23, which are pivoted on to the after cover of the clutch casing. Keyed on to the clutch shaft inside the casing is a drum which is encircled by the coils, and on the other end of the shaft is fitted a half coupling for connecting the clutch shaft to the propeller shaft or reversing gear. The clutch is operated by the lever shown in Fig. 21. The lever engages with a sliding sleeve on the clutch shaft, and this sleeve carries at its forward end a cone-shaped part, on which the longer arms of the bell-crank levers rest. When the lever is pushed forward, as indicated by the dotted lines in Fig. 21, the bell-crank levers are turned so as to tighten the coils on the drum and thus the power is transmitted to the propeller. The two positions of the cone and sleeve are indicated in Fig. 21, that above the shaft axis being the position when the clutch is disengaged, and *vice versa*. When the clutch is engaged, there is little or no thrust on any of its bearings, the propeller thrust being taken by the ball thrust bearing shown on the right-hand side of Fig. 21; the other thrust washers shown take the thrust when the clutch is disengaged. It should also be mentioned that the grip of the coil springs can be adjusted to compensate for wear by slackening the bolts which secure the after cover of the casing and slightly turning the cover in the opposite direction to that in which the engine runs; the bolt holes in the cover are slotted to enable this to be done. The wear, however, is very slight, since the clutch casing is kept partly filled with oil.

Details of the reversing gear, which, as previously stated, is fitted on the starboard engine shaft only, are given in Figs. 24 to 27. Its action will be most clearly followed by an inspection of Fig. 24, in which it is shown in the neutral position. By moving the sliding gear on the tail shaft towards the left of the illustration a direct positive drive is obtained, an internal gear on the sliding gear then engaging with a corresponding external gear on the engine shaft. The latter is connected to the lay shaft by means of a twin roller chain and by moving the sliding gear to the right, the latter is brought into engagement with a pinion on the lay shaft, so that the tail shaft is driven in the reverse direction and also at a reduced speed; the speed reduction is in the ratio 3 to 2. The sliding gear is moved by the handle shown in Fig. 26, the lower end of the vertical spindle carrying a pinion which gears with a rack out on a sliding bar, indicated by dotted lines in Fig. 27. The sliding bar carries a fork which fits in a groove in the sliding gear, as will be clear from an inspection of Figs. 25 and 27. The brake drums shown in Figs. 24 and 27 are provided for the purpose of holding both shafts stationary while changing gear.

Having now completed the description of the main features of the vessel and its equipment we may conclude our article by a brief reference to the voyage made from Westminster to Cherbourg on December 7 and 8 last, when the boat was delivered to the French naval authorities. Personal references are usually undesirable in a technical description, but we think it is of sufficient interest to refer to the fact that the boat was navigated to Cherbourg by Lieut. J. W. Thornycroft, R.N., the grandson of the designer, who was himself running the trials of his first torpedo boats there 45 years ago. The boat left Westminster Pier at 11.45 a.m. and arrived at Dover at 2.6 p.m., the intervening distance of 82 sea miles having been covered in 2 hours 21 minutes; the mean speed was therefore 34·9 knots. The next stage of the journey, from Dover to Portsmouth, a distance of 106 miles, was covered in 3 hours 5 minutes, the mean speed on this stage being practically the same, viz., 34·4 knots, although a heavy swell and some fog were encountered *en route*. The journey from Portsmouth to Cherbourg, 77 miles, was completed when strong tides and a rough sea, which became worse as the French coast was reached, had to be contended with. The time taken for this part of the journey was 2 hours 30 minutes, giving a mean speed of 30·8 knots. The total running time for the whole trip of 265 sea miles was thus 7 hours 56 minutes, and the average speed from Westminster to Cherbourg comes out at 33·4 knots. This, we think, is a very creditable performance and is effectual evidence of the seaworthy character of the boat.

INDUSTRIAL NOTES.

As the Ministry has decided to hold a court of inquiry into the engineering dispute, it is to be hoped that the employers will take care to have their side of the case adequately put forward. It would be disastrous to have a repetition of the state of affairs at the coal inquiry, where the miners were represented by expert political polemists up to all the tricks of their somewhat unsavoury trade, and adepts at the art of making the worse appear the better reason. The employers' representatives, on the other hand, really were, what Mark Antony merely pretended to be, viz., plain, blunt men, quite incapable of countering the nimble and experienced controversialists on the other side. The golden opportunity of permanently discrediting Mr. Sidney Webb by subjecting him to an effective cross-examination was, in fact, wasted, and is hardly likely to recur. The country may be trusted to judge fairly in the present dispute, if the facts are fully brought before it, but many juries would return wrong verdicts if one side were represented by a leading K.C. and the other by a barrister just called.

The public in general undoubtedly condemns the "ca-canny" policy which still finds such strong support in trade union circles. Indeed, many of the workmen themselves acknowledge its innate folly. Some little time back a works manager, on entering the machine shop noticed that all the machines were being run at the lowest possible speed. Being on good terms with his men he inquired the reason, and was told "We know it's a' wrang, but them's oor orders." It is, however, of the utmost importance that such cases shall be established before the court on incontrovertible evidence, and there should also be laid bare for all to see the real nature of the "hardly-won rights and privileges" of the union. It would be well also to get into the box the most prominent labour leaders, and extract from them an opinion as to the righteousness of fining moulders who worked 10 minutes overtime in order to save an important casting. Admittedly there have been wrongs on the other side, but only good would result if the inquiry also brought these to light, as the general body of employers will be the first to reprobate unfair practices by individuals, which in the end react adversely on their own relations with their men. There is, however, this distinction between the two cases, that the wrongs done on the workman's side are the fault of the union, which as has been said of some other corporations has neither a body to be kicked nor a soul to be saved; whilst the wrongs from which the men suffer are due to the action of individuals, and are unsupported by the general body of employers.

The engineering employers are opening their shops to all who are prepared to accept their terms. It will be of great interest to know what the response will be. We are told that very large numbers of men are extremely dissatisfied with the union, and only join it to secure a relatively peaceful life. On the other hand, the union officials express themselves as very confident that there will be little response to the employers' appeal. Time will show which view is right, but it has, of course, to be borne in mind, that a certain amount of intimidation is sure to be exercised by the officials. The serious condition to which the "hard-won rights and privileges" of the union have reduced the engineering trades is a very grave matter, but in the end the British workman has a saving fund of commonsense, and is not likely to fight very keenly to maintain conditions which he "knaws are a' wrang."

The British iron and steel trades are now beginning to feel the effects of the engineers and shipbuilding strike, which is considerably limiting business in the home market. The pig-iron market has been the one to benefit the most from the demand from overseas, and this has enabled the producers to maintain their prices, and also to avoid putting iron into stock. One of the best export customers has been Germany which, during the past few weeks, has bought about 12,000 tons of iron. Other countries which have bought good quantities have been Belgium, France, and Italy. In the semi-finished department there has not been a great deal of business passing of late, but an increase in the volume of inquiry indicates that consumers are keeping in touch with the market. Whilst the present labour troubles last, however, it is unlikely that there will be a brisk demand for semi-finished materials. The request for finished iron and steel descriptions has also dwindled. Manufacturers, however, anticipate an improved business with overseas markets, owing to the sharp advances in American prices which have followed the coal strike in that country. Immediately prior to that dispute considerable competition was being experienced from America, particularly in India and the Far East; but the increases in the American prices have been followed by a considerable expansion in the inquiries from abroad.

According to *The Sheffield Daily Telegraph*, the action of a trade union has led to a remarkable position at a mill in the Chorley district of Lancashire. This mill, which employs between 500 and 600 workpeople, of whom about 5 per cent. are spinners, has for a long time started work at 7 a.m. The Bolton Spinners' Union, within whose area it is, intimated to their members at that mill that they should start at 7.45. On account of the local conditions the operative spinners favoured 7 o'clock, and, as they did not obey the order, they were suspended from membership of the union. They dared not further resist, as most of them have almost qualified for superannuation benefit, and so they had to give in or lose the payments of many years. The result is that the mill is to start at the time stated by the union—an alteration which has not a single supporter in either spinning or weaving departments.

Miners' wages in South Wales during May will remain at the minimum of 28 per cent. on the 1915 standard. The joint auditors' certificate shows that the financial condition of the South Wales coal industry during March records an improvement over that of the previous month. The disposable surplus is 227,837*l.*, of which 83 per cent. would go to the workman and 17 per cent. to the coalowners, but the total is not enough to pay the minimum rate of wages to the men. Therefore, the owners sacrifice the whole of their share of the surplus and also 171,371*l.* of their standard profits. This brings the owners' total loss for the five months of the National Agreement to 1,300,000*l.* In view of this, the speech made on May day by Mr. Vernon Hartshorn, M.P., is distinctly surprising. He said that the Welsh coalowners had been hawking the Welsh miner round the markets of the world, and selling him as a slave to foreign buyers. The time had come when the Welsh miners must consider whether they were going to submit any longer to the conditions which they had lived in during the past months. If there were shown at the pending conference a disposition on the part of the men to stand up against the treatment, they would find that they had a body of leaders who would organise and lead the fight. During the winter it was not the time to put up a fight, but he believed that when the warm weather came the psychology of the Welsh coalfield would completely change.

It was to be hoped that the record of the last few months would have brought men to realise that the foreign buyer has no intention of giving more than a fair equivalent for such commodities as he may require from us. In exchange for our coal, say, the foreigner gives us farm produce, but he is not prepared to give produce which requires perhaps three days' work to produce, for the product of a few hours' labour by a Welsh pitman. Nor is it reasonable that he should be asked to do so.

The May wages of miners in the eastern area, comprising Yorkshire, Nottinghamshire, Derbyshire, Leicestershire, Cannock Chase, and Warwickshire, will be about 10 per cent. under the April rate.

For using violence with the object of intimidating a workman at Cammell Laird's, Birkenhead, three members of the Amalgamated Engineering Union were convicted at Birkenhead on Tuesday. Michael George, a former local secretary of the union, alleged to have struck the man and knocked two of his teeth out, was fined 10*l.* The other two men, William Yonds and James Stapleton, were each fined 5*l.* The man was held up on his way to the shipyard and so severely handled that he had to be assisted home. The defence was a total denial of the assault, which it was submitted was committed by other members of the crowd.

The registers of the Unemployment Exchanges in Great Britain on April 24, contained the names of 1,640,100 persons registered as wholly unemployed, as compared with 1,633,926 on April 17, an increase of 6,174 in the week, but a decrease of over 183,000 in the last 15 weeks. This total was exclusive of short time workers, and also of persons unemployed owing to

trade disputes. On April 24 there were 174,700 persons working short time, compared with 187,027 the previous week. In future the weekly return will relate to Great Britain only—not to the United Kingdom, as previously. The number of persons on short time and claiming unemployment benefit has varied as follows:—July 1, 1921, 934,786; February 28, 1922, 241,847; March 27, 1922, 205,475; April 24, 1922, 174,700.

It is now possible to give an outline of the new constitution of the Transport Workers' Federation, which embraces a million and a half men. It has been decided to enlarge the Executive by the inclusion of the representatives of the three railway unions—the National Union of Railwaymen, the Locomotive Engineers and Firemen, and the Railway Clerks—and to modify the rules to meet exigencies of the future. It is proposed to sub-divide the new Executive into four group sub-committees dealing respectively with: (1) Docks and inland waterways; (2) railways; (3) road transport (passenger and commercial); (4) overseas transport (seamen and firemen). The object of the new constitution is defined as being "to uphold the rights of combination, and to improve the economic status of the transport workers." It is claimed that the new constitution will make the Federation more powerful and influential than ever.

DISINTEGRATION AND EVOLUTION OF THE ELEMENTS: CORRECTION.—On page 495 of our issue of April 21, we stated in the twelfth line from the bottom of the first column: "Similarly an α particle shot against a foil of a heavy metal would not penetrate into it." We should rather have said: "might not penetrate or, at any rate, not cause disrupture." Further, the last sentence of the first paragraph of the third column, on the same page, should begin: "In order to keep out β particles (not α particles).

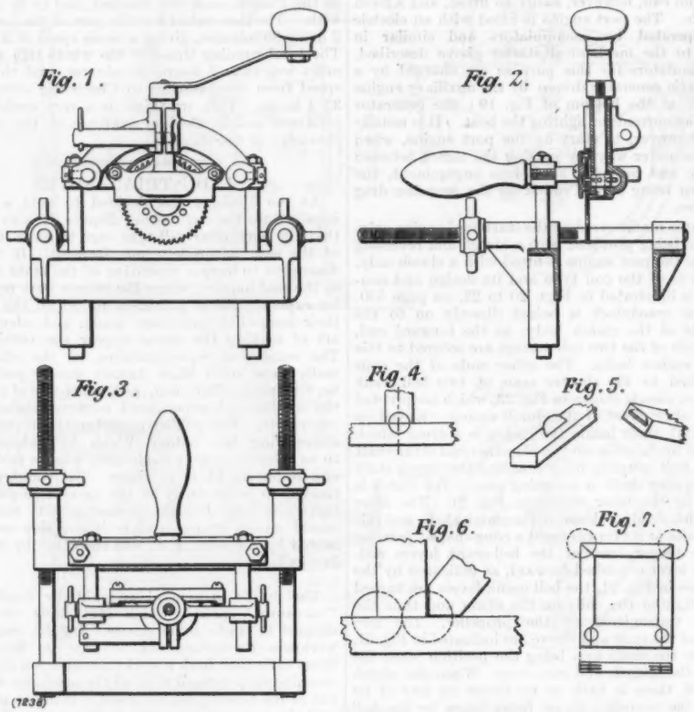
THE SURVEYORS' INSTITUTION.—The next county meeting of the Surveyors' Institution will be held at Shrewsbury on June 14, and the following days. There will be a reception by the president on the evening of June 14, and on the following day there will be an official welcome by the city authorities. Visits have been planned to various places of interest in Shrewsbury, to the works of the Sentinel Wagon Company, to Powis Castle, and to Lake Vyrnwy. The official quarters at Shrewsbury will be the Raven Hotel.

FAILURES OF SILICON-IRON IN FUMING SULPHURIC ACID.—Though cast iron is a suitable material for containers and pipes of ordinary sulphuric acid, it is not reliable for fuming sulphuric acid. Heavy cast-iron pipes and valves for this strongest acid are apt to crack, sometimes quite suddenly and with a loud report, although there is no visible corrosion. Malleable castings may likewise fail. It has generally been assumed that the fuming acid penetrates into the pores of the metal where the SO_3 is reduced to SO_2 and to H_2S, while the carbon is oxidised into CO_2, and that the pressures of these gases strain the metal. In the *Journal of Industrial and Engineering Chemistry* of April, T. F. Banigan, of the Hercules Powder Company, California, suggests that the main cause of the failure of siliceous iron is the formation, by the action of the SO_3, of crystallising silica SiO_2. The analytical detail which he gives shows that silica is formed when silicon iron, highly resistant to non-fuming acid, is immersed in fuming sulphuric acid. But he supplies no proof for his assertion that the silica would crystallise and thus set up internal strains in the iron; the silica which he observed was gelatinous.

STRESSES IN SHIPS' BODIES.—Just before the war Dr. Siemann, of Bremen, made some measurements of the stresses which the Norddeutsche Lloyd steamers George Washington and Bremen were undergoing when in motion. The apparatus of which he availed himself was a kind of Martens mirror extensometer, which did not prove convenient for the purpose; it took a long time to mount the instrument. When recently resuming those measurements, he therefore adopted another arrangement, which he described in the *Zeitschrift des Vereines Deutscher Ingenieure*, April 15. A bell crank lever is operated by changes in the stresses which a length of 200 mm. of the ship's hull is undergoing; the lever presses against the diaphragm of a hydraulic indicator, the capillary of which is charged with coloured alcohol. The instrument bears with three conical points against the body, being held in position by the aid of clamps. One of the conical feet is especially adjustable for correcting the zero, and the joints of the instrument are of the flexible diaphragm type. Kinematic records are obtained by placing the capillary between a lantern and a moving film. The article mentioned reproduces the records secured during the launching, at the Vulcan shipbuilding yards, Bremen, of the steamer Köln. The curves show the change of the downward pressure into an upward pressure, and the subsequent diminution of the latter pressure, as the ship left the slipway, struck the water and then floated freely. The observed change in the stress was 230·4 kg. per square centimetre, whilst the calculated value was 237 kg. per square centimetre. The instrument was calibrated on a tensile traction machine, being clamped for this purpose to an 8-in. rod which was loaded; the load on the machine was indicated by an oil gauge, which agreed closely with the hydraulic gauge of the instrument.

THE "DISKEY" SAW.

CONSTRUCTED BY MR. EDWARD W. HOBBS, ENGINEER, HORSHAM.



(7238)

THE "DISKEY" SAW.

AT the recent "Model Engineer" Exhibition in the Horticultural Hall, there was shown an interesting little appliance which appears likely to find a considerable sphere of usefulness amongst those engaged in the wood-working trades. Its function is to eliminate the need for making mortice and tenon joints by providing an alternative form of joint which needs no particular skill on the part of the operator. The joint is made by embedding one or more circular discs in three-ply wood in semi-circular recesses cut in the pieces to be connected. Each recess is an exact half-circle, so that the junction of the pieces of wood lies right across the diameter of the inserted disc. It is obvious that an ordinary saw when fed into a solid piece of wood cannot cut a full half-circle because the spindle of the saw would prevent the saw entering the wood to the required distance. In the appliance to which we have referred the saw has no spindle, but is driven by a studded pinion gearing into holes through the body of the saw. Figs. 1 to 3, annexed, show the apparatus. It consists of a malleable iron frame arranged to act as a workholder or clamp. The frame carries a pair of steel columns with a cross-bar at the top, the cross-bar having two arms which support the saw frame. The latter is adjustable along these arms to enable the slot to be cut at any desired position or spacing. There is a separate angular adjustment about the axis of the saw drive spindle, which enables the slots to be cut at any angle.

The saw is 3 in. diameter and 4 mm. wide over the teeth. It rides on a detachable, hardened steel centre disc, and is driven by a peg gear, as already mentioned. A light cover with pressure pads, and relief holes to clear the chips, prevents the saw from shifting its position. To use the apparatus the frame is first set so that the saw is at the correct distance from the face of the work. The latter is then inserted in the cramp, the saw is rotated by the handle and forced down into the work as far as it will go. A full half-circular slot, 3 in. diameter by 4 mm. wide, is cut in ordinary wood in about 65 seconds. Figs. 4 to 7 illustrate the nature of a few of the many kinds of joint, of which the little machine is capable. Its portability is a great advantage, as work can be done practically in position, and in the cabinet-making, pattern-making, furniture making, building and other trades the facility which it affords of making a cheap and effective joint between pieces of wood should render it appreciated. It is sold by the inventor, Mr. Edward W. Hobbs, Friday-street, near Horsham, Surrey.

THE SPEARING WATER-TUBE BOILER.

IN view of the position which the water-tube boiler has taken in modern steam-raising it is perhaps matter for some surprise that a larger number of firms have not concerned themselves with its manufacture. The water-tube boiler trade has, however, been in comparatively few hands, and there should be ample room for the products of the Spearing Boiler Company, Limited, which has comparatively recently been formed. This firm, which has its offices at Bank Buildings, 20, Kingsway, W.C. 2, has purchased a controlling interest in the old-established and well-known firm of boiler makers, Messrs. Tinkers, Limited, of Hyde, near Manchester, and the Spearing boiler will in the future be made at Messrs. Tinkers' works. On Friday last, by the courtesy of the Spearing Boiler Company, we had an opportunity of paying a visit to Messrs. Tinkers' works, in which various Spearing boilers were under construction, in addition to Lancashire and other boilers representing Messrs. Tinkers' original lines of manufacture. The present capacity of the works is somewhat over three Spearing boilers a week, but further plant is being installed and the works, which have ample room for extension, are to be doubled in size. This will provide a capacity of at least ten large Spearing boilers a week.

The Spearing boiler, although of modern design, is in no way an untried novelty. Its essential features were first tested some twelve years ago, and the boilers then built have since been in continuous and satisfactory service. Various improvements have been made since the initial installation, and the boiler as now manufactured represents many years of development and experience. Two types of the boiler are built, the first having a longitudinal drum and the second cross-drums. Both of these types embody the special features of the Spearing boiler, and we may confine our description to the cross-drum type, which is employed for all larger capacities and is, consequently, perhaps of the greater interest from the point of view of modern power station work.

The boiler has straight tubes expanded into straight headers. There are two upper cross-drums, a steam drum at the front and a water drum behind, and a lower mud drum at the back of the boiler below the back nest of headers. The front headers are connected to the steam drum at their top ends and the back headers are connected to the mud drum at their lower ends. Communication between the water drum and the back headers is established by means of downcomer pipes

TRAVELLING GANTRY MULTIPLE DRILLING MACHINE.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, ENGINEERS, NEW YORK, N.Y., U.S.A.

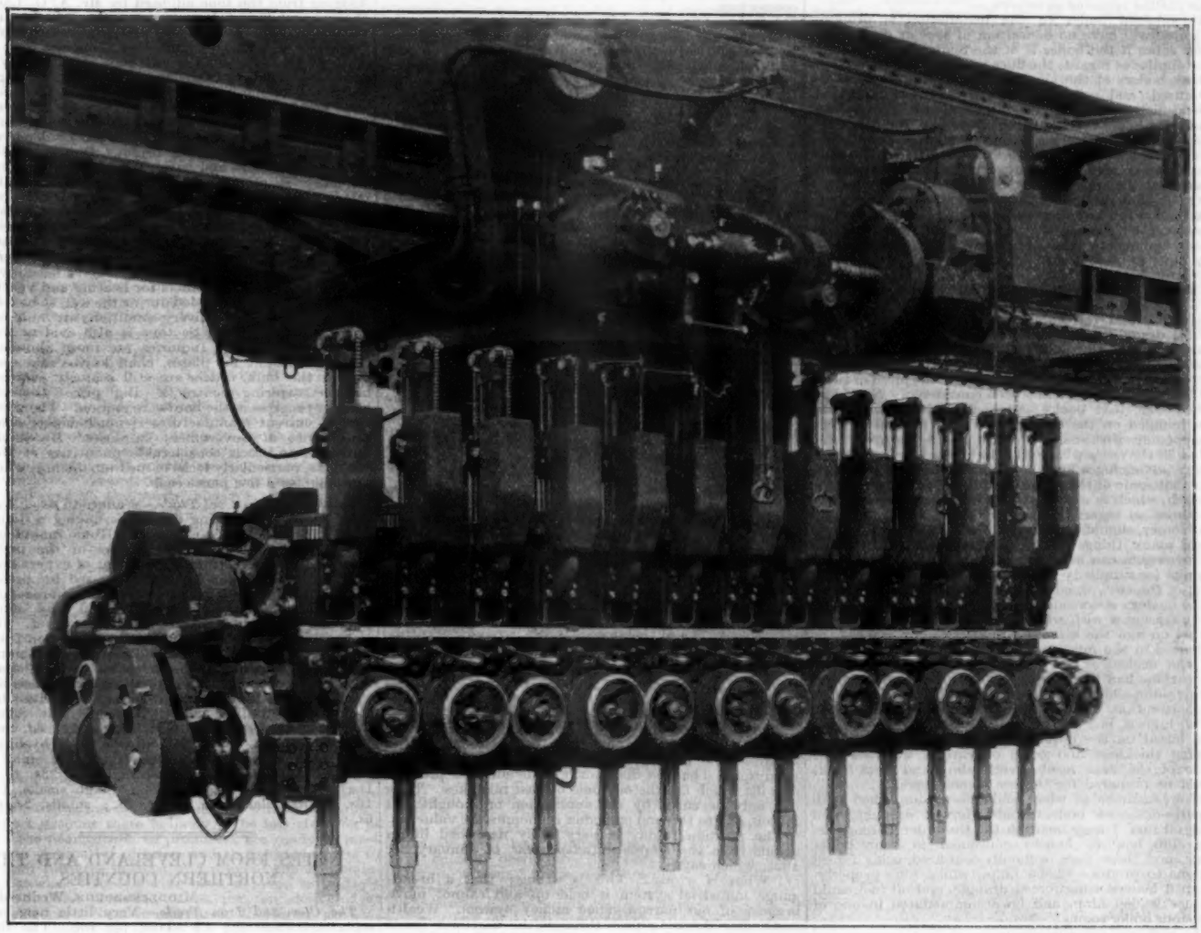


FIG. 1.

which connect the water and mud drums. The result of this arrangement is that all water is circulated through the mud drum which collects and retains any deposit, some of which would otherwise be distributed through the headers and on the steam generating surfaces. Connection between the mud drum and the back headers is through short nipples, and a further result of the general lay-out is that all circulating water enters these headers from their lower ends. This gives a very efficient water supply to the lower rows of tubes. The consequence is that these tubes play a very important part in the steam generation, the main fall in temperature of the furnace gases taking place in passing the first five rows of tubes. In spite of the position of the lower tubes directly exposed to the fire the efficient circulation prevents blistering. The qualifications of the boiler in this respect are especially marked with oil firing.

As already mentioned, the headers are straight. They are of rectangular section and are solid drawn. It is claimed that this construction gives a freer circulation than a sinuous header, and also that a more uniform thickness of metal is obtained, and that there is less deformation of the material during manufacture. The tubes are staggered by about 1 in., the headers being wide enough to allow of this. This staggering facilitates the removal of soot. The caps, which are fitted to the headers opposite the tube ends, are of the internal type, the holes they cover being oval and the caps made on the lines of a mud hole door. With such internal caps the internal pressure assists in maintaining the joint. The straight headers, of course, assemble neatly side by side and allow of an efficient and easily made airtight joint. All Spearing boilers are fitted with Ferguson patent sectional superheaters, in which each section consists of a U-shaped tube terminating in flanges which are bolted to the superheater headers. Any section can be removed without disturbing any other section or any steam pipe connection, and when a section is removed blank flanges can be placed on the openings so that the superheater as a whole can continue working. We hope later to have an opportunity of reproducing drawings of a Spearing boiler.

TRAVELLING GANTRY MULTIPLE DRILLING MACHINE.

AN unusual type of multiple drilling machine is illustrated on this page and on page 556. The views on the latter (Figs. 2 and 3) show the same side of the gantry, but give the revolving cross-rail in two positions. Fig. 1 annexed shows in greater detail the cross-rail carrying the drilling heads. The main features of the machine are that it carries 13 drilling spindles while the gantry has a span of 44 ft. The gantry is composed of two double-webbed girders braced together with lattice bracing and carried by two heavy legs of cast-iron, each mounted on two wheels. The latter are arranged to run on a track laid on the shop floor, and a motor is provided capable of traversing the gantry at speeds ranging from 5 ft. to 50 ft. per minute. The higher speeds are used for the longer distances, and the low speeds for short lengths or setting. Hand adjustment is also provided. A dial is arranged in one leg registering feet and inches, to assist in setting.

From the gantry girders is hung a carriage on rollers. This carriage is also furnished with a small traversing motor as will be clear from all our illustrations, this being controlled by handles hung to within reach of the operator, easily recognisable in Fig. 1. Under this carriage is hung the swivelling cross-rail casting which is capable of turning through 360 deg. This movement makes it possible to drill rows of holes running in any direction. A small motor to be seen at the back of the cross-rail is provided for revolving this part of the machine. Hand motion is also furnished.

The cross-rail carries the drilling heads to the number of 13. The machine is provided with power and speeds, &c., suitable for drilling, tapping, &c. In the case of drilling, all 13 heads can be run simultaneously drilling 1⅛ in. holes, while 13 1¼-in. holes can be tapped at one time. The cross-rail is graduated its full length for setting, and the heads can be clamped and also the rail clamped in position on the carriage. All heads are adjustable as to position on the cross-rail, except an end one; all the others can be moved simultaneously or independently by a screw extending the full length of the rail. The maximum distance apart of the outside spindles is 12 ft. 8 in., and the minimum distance from centre to centre of any two, 8 in.

The spindles are of chrome nickel steel. They have a vertical adjustment of 13 in. They are driven by a reversing 50-h.p. motor, which will be seen in Fig. 3 at the back of the cross-rail. A safety device is incorporated in the feed gearing, to prevent damage in the event of an accident to any of the drills.

The distance from the floor plate to the underside of the gantry girders is 8 ft. 6 in. and to the top of the girders a further 3 ft. 8 in. The machine weighs about 35¾ tons. It has been constructed by the Niles-Bement-Pond Company, of New York, whose London offices are at 25, Victoria-street, S.W. 1.

OIL-FUEL BURNING.

TO THE EDITOR OF ENGINEERING.

SIR,—You published a letter of mine in your issue of March 24, page 370, in which I pointed out the need of special attention being given to the design of boilers intended for the use of oil fuel, and I desire to make some further remarks as follows:—

An oil-fired boiler (if the installation is properly designed) will have no deposition of soot or dust in the boiler tubes if the boiler is of the Scotch type, and the same applies as regards the flues in the case of Lancashire boilers, boilers of the vertical type, or those which are underfired, and consequently the boilers will have a higher efficiency through cleanliness alone. This applies equally to boilers of the water-tube type, but there are other considerations, viz., that in the case of boilers where economisers and superheaters are fitted, it becomes a necessity to give attention to the design of the economisers and the superheaters, owing to the fact that the flue gases of an oil-fired boiler are much lower in temperature than in the case of a coal-fired boiler, and it becomes necessary to consider the best position for the superheater, and also to consider how much its heating surface may have to be increased to produce the desired superheat temperature.

The size of chimney, as regards diameter and height for a given duty, has apparently never been sufficiently considered, and the value of fan draught as against natural draught has never been sufficiently considered in the light of the new factors which enter into the question of oil-fired boilers. In the case of Scotch boilers and certain classes of water-tube boilers the pitch of tubes and bore of tubes have not been considered. Nearly all table books, text books and pocket books have their data founded on the experience of the general average of happenings with coal, and therefore they are practically useless in the cases where oil is to be used as fuel, and as we are advancing a step beyond the coal age it is high time that some of that energy, dilligence and instinct for research, which is a remarkable and splendid feature of the times as regards the engine-room of a steamship or a factory, should be devoted in part to the boiler room, where many things need attention, and where many improvements can be accomplished to effect economies, to make for simplicity of working, and to cut out something of the cost, weight, and space occupied by boilers in the modern steamship.

The tenseness with which the pursuit of economies is carried on and the attempts to effect improvement, as evidenced in the modern steam turbine, are admirable, but the neglect of the boiler room is a marvel to me. The turbine had been improved, also the condenser and the air pumps have been seen to, but the boiler room is worth attention. The value of forced or induced draught is well known, but as all past experience with such has been based on the requirements of coal (with fires of varying thickness and coals of various qualities) the whole of the data needs overhauling and new books should be prepared for the use of engineers.

As an instance of what could be accomplished with properly-designed boilers under forced draught, and using oil fuel, I may mention the Cunarder Berengaria. This ship has 46 boilers contained in four boiler rooms, and these were originally coal-fired, using forced draught to produce 62,000 i.h.p., whilst nine properly-designed boilers using forced draught and oil fuel could produce 90,000 i.h.p. and be accommodated in one of these four boiler rooms.

The new and valuable departure of the Institution of Mechanical Engineers in extending the scope of its operations to the provinces will be a great help to the cause of advancing engineering science and practice, and as the prevalent idea in connection with oil fuel is that it is purely a matter of suitable oil burners, this letter may cause many engineers who are interested in the subject to pause a moment and reflect, and then they will understand that it is a subject which has up to the present been misunderstood, and in many cases badly handled. It is not a question of burners merely, but one of all round design of the features that will put the oil-fired steamship of high power on terms approaching the economies effected by the use of a well-designed internal-combustion engine, such as is now a feature of some of our modern ships of moderate power and speed.

The design of a boiler so that the best use can be made of it involves questions of suitable heating surface, and suitable combustion space, and suitable funnel areas and heights (and in the case of the water-tube boilers suitable provision to baffle the gases in the best manner); these are all points for the engineer, and are worth quite as much attention as is now almost exclusively paid to the engines.

Yours faithfully,
J. J. FERMODE, M.I.Mech.E.,

35, The Temple, Dale-street, Liverpool,
April 28, 1922.

DOUBLE-REDUCTION GEARS.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been called to the report in your issue dated April 14, 1922, concerning the discussion at the recent meeting of the Institution of Naval Architects, on the double-reduction gears of the S.S. Melmore Head, described in the paper, by Mr. J. W. Wilkie, and I shall be obliged if you will kindly correct my remarks, which should read as follows:—

Mr. Walker has referred to certain cases of fractures in the teeth of nickel steel pinions, and I may say that a tooth has broken in the Conte Rosso. The Parkhead Steel Works of Messrs. William Beardmore and Co., with which I am connected, are most anxious to collaborate with the engineers, and to find out exactly what is wrong with the material, if there is anything wrong with it; they are anxious to find out what is the best steel to be used whether it is nickel, nickel-chrome, or nickel-chrome-vanadium, and I am quite sure that all the steel-makers in the country are equally anxious.

It is obvious that the elastic limit and the heat treatment must play a very important part in this connection.

I feel certain that, with simplicity in design, good workmanship and the best material, double-reduction gearing will win in the end, and will give that economy and reliability which shipowners and superintendent engineers naturally look for.

Yours faithfully,
W. ONYON,
Engineer-Captain R.N. (Retired).

Naval Construction Works, Dalmuir, Dumbartonshire,
April 28, 1922.

"REMEDY FOR SHRINKAGE IN WORLD'S OVERSEA TRADE."

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent, Alfred Bigland, in the issue of April 21, gives what, in his opinion, would rectify the chaotic state of the world as regards industry and finance, but so far as I can judge his is merely another quack remedy and only worthy of his waste paper basket.

He states one remedy—"by twenty or thirty years' scraping, saving and hoarding"—with which I entirely disagree, as by doing so he is only decreasing the amount of money available as purchasing power, and as purchasing power is necessary in order that the people may be able to obtain the commodities produced for their consumption he would have exactly the same state of affairs as at present, viz., under-consumption.

His other remedy—"by making legal tender . . . of silver in a ratio to gold"—is, in my opinion, likewise useless since he is only transferring a standard from one metal to another of less value. Any standard of value based upon gold, silver or other substance, is liable to fluctuate with the amount of money in circulation, and hence is no standard at all.

My way of looking at a standard is this: Take a standard yard, *i.e.*, 36 in. Now a standard yard is only standard when it is 36 in., but if, for some reason, the standard yard fluctuates and becomes 18 in., it is no longer a standard. That is exactly what happens with money. The more money put on to the market without a corresponding increase of goods for consumption, which is what is always done and is known as inflation, the less does its value become so that the supposed standard is no standard.

The policy of sixty years, 1814–73, as proved by to-day's state, has been no remedy, otherwise had it been so we should not have found ourselves in our present condition. The past does not provide cures for present-day ills which are the outcome of past mistakes. They can only be cured by the application of thought and reason, and to this end orthodox economics are valueless.

The position to-day is very aptly described in an article from the *Dearborn Independent*, of January 28, 1922, which says:—

"What is wrong? This is wrong; that a broad-gauge industrial system is held up and cannot move because of our narrow-gauge money system. Wealth must slow down to pass through the narrower gates of money, because there is more wealth than there is money to move it. And money itself must slow down to pass through the still narrower neck of gold, because there is more money than there is gold to validate it."

The problem must be tackled in relation to industrial development and progress, and this will only be obtained by the institution of the "*Just Price*" and with it "*Communal Control of Credit.*"

Yours truly,
JAMES ADAMSON.

25, Lesbury-road, Newcastle-on-Tyne,
May 1, 1922.

"PATENT OFFICE METHODS."

TO THE EDITOR OF ENGINEERING.

SIR,—I note with interest you have printed my note to you *re* "Patent Office Methods."

I would venture to point out that there is an error in printing the last paragraph; you have used the word "pay," this should read "pray." As printed the point in this paragraph has a very different meaning. The actual wording is even more menial than shown. If you turn up Patents Form No. 1 you will see it reads as follows: "I (or we) *humbly pray* that a patent may be granted to me."

Yours faithfully,
W. STEEL PARSONS.

Radford Bridge, Enstone, Oxfordshire,
April 29, 1922.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: METROPOLITAN DISTRICT.—A meeting of the Metropolitan District of the Institution will be held on Friday, May 12 next, at 4 p.m., at the Holborn Borough Council Offices (opposite British Museum Tube Station) to consider the Report and Recommendation of the Executive Committee on a communication received from the secretary of the Institution with respect to the revision of the areas allotted to the different districts of the Institution. As this is a subject of considerable importance to the Metropolitan District it is sincerely desired that every member, associate member and student of the Metropolitan area will make an effort to be present.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Some satisfaction is expressed at the relief contained in the Budget, but the general impression among steel-makers is that tax reductions do not go far enough greatly to improve the industrial prospect. Judging from the tone adopted by Mr. A. G. Longden, chairman of Henry Bessemer and Co., Limited, one of the leading firms in the heavy section, a return to normal conditions is a long way off. Mr. Longden went so far as to say that he could see no hope of an improvement in the steel trade in 1922. This, of course, represents the worst side of the picture. Crucible steel, perhaps more than any other section, has been severely in the dumps for some months, and with heavy stocks remaining at works and under release by Government departments, the outlook is anything but bright. On the other hand, in the implement and machinery sections an upward tendency is maintained. Manufacturers are able to offer contract rates for forward delivery which compare favourably with those of foreign competitors. Australia, New Zealand, Canada and the far eastern markets are taking a much more active interest in quotations, and buyers on home account are placing orders for renewals with greater freedom. Instructions have been given for several substantial contracts for heating and ventilating plant, which was suspended during the war, to be resumed now that prices and delivery conditions are more favourable. A more optimistic tone is also evident in agricultural machinery. Inquiries are more abundant on Colonial account for plates, chaff knives and castings, but in the bulk, orders are still scarcely sufficient to balance expiring contracts. Big price discrepancies hamper progress in the hardware section. The wholesale cost of current manufactures is much higher than the retail price of Government surpluses. Merchants are putting into stock considerable quantities of German products, particularly locks of medium quality, which are available for a few pence each.

South Yorkshire Coal Trade.—Failure to reach a settlement in the engineering dispute is having a damaging effect on business in steam coal. Home manufacturers are buying very sparingly because of the uncertain outlook. There is still a fair amount of export business passing, but collieries are being pressed for price concessions. Movement in gas fuels is rather more restricted. Reduced consumption for industrial and domestic purposes is having a marked effect on output. Benefit is expected to accrue to the small coal section from the settlement of the dispute in the Lancashire cotton trades. Business in best quality house coal is easier all the way round. Stocks are being reduced and purchases limited in the hope of lower prices. Quotations:—Best branch handpicked, 38*s.* to 39*s.*; Barnsley best Silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 32*s.* 6*d.* to 34*s.*; Derbyshire best house, 26*s.* to 28*s.*; Derbyshire best large nuts, 24*s.* to 26*s.*; Derbyshire best small nuts, 16*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 22*s.*; rough slacks, 14*s.* to 16*s.*; nutty slacks, 8*s.* to 9*s.* 6*d.*; smalls, 2*s.* 6*d.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Very little new can be reported concerning Cleveland pig-iron. The limited output continues fully absorbed, and there is marked scarcity of No. 1 and forge qualities. Business with Scotland has shrunk to very small proportions, and is based on 96*s.* 8*d.* f.o.t. Grangemouth for No. 3. Market prices for despatch to all other destinations at home and abroad are f.o.t. at makers' works, or f.o.b. Tees, and remain: No. 1 and siliceous iron, 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 85*s.*; and mottled and white, 80*s.* Continental inquiries were reported falling off.

Hematite.—Supply of East Coast hematite has become quite plentiful. Some makers have fairly good order books and are not pressing sales at the reduced figures, but others are short of work, and are very keen to secure contracts. No difficulty is now experienced in purchasing Nos. 1, 2 and 3 at 96*s.*, both for home purposes and for shipment abroad, and indeed rather considerably below that figure is understood to have been accepted. On the other hand there are producers who still ask 97*s.* 6*d.* No. 1 is a shilling above mixed Nos.

Foreign Ore.—There is little doing in foreign ore. Mediterranean kinds range from 22*s.* to 23*s.* 6*d.* c.i.f. Tees, and there are sellers of best rubio at 27*s.* c.i.f. Tees.

Coke.—Though coke shows a tendency to ease, local consumers still have to pay up to 28*s.* delivered for early supplies of average blast-furnace Durhams. Forward contracts, however, can be made at a good deal less.

Manufactured Iron and Steel.—The various branches of iron and steel present no new feature of particular moment. Orders for despatch to foreign destinations would readily be accepted at below the following rates which rule for home trade:—Common iron bars, 12*l.*; iron rivets, 14*l.*; steel billets (medium), 8*l.* 5*s.*; steel billets (heavy), 8*l.* 15*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; heavy steel rails, 9*l.* 10*s.*; fishplates, 14*l.* 10*s.*; and corrugated galvanised sheets, 16*l.* 5*s.*

Shipments of Iron and Steel.—Official statistics show that last month 86,902 tons of iron and steel were shipped from the Tees. Of this total, 44,183 tons were pig-iron, of which 5,665 tons went from Middlesbrough's neighbouring port of Skinningrove; 5,930 tons were manufactured iron; and 36,789 tons were steel. Germany was

not only the largest customer for pig-iron, but that country took in April more than the total Middlesbrough loadings for abroad during any month last year. Germany's April imports of pig-iron reached 11,532 tons, and among other chief customers were: Wales, 9,160 tons; Belgium, 4,501 tons; Italy, 3,045 tons; France, 2,235 tons; Japan, 1,600 tons; Sweden, 1,435 tons; and Scotland, 1,370 tons. India was again by far the heaviest receiver of both manufactured iron and steel, taking 5,097 tons of the former and 16,968 tons of the latter. Other principal importers of steel included: Cape Colony, 3,431 tons; Peru, 2,085 tons; the Gold Coast, 1,478 tons; China, 1,424 tons; the Straits Settlements, 1,374 tons; and Victoria, 1,071 tons.

Imports of Iron and Steel.—Returns published this week by the Tees Conservancy Commission show that for the half-year ending April 30 imports of pig-iron to Tees ports from Holland, France, Norway, Sweden, Germany, and coastwise reached 30,160 tons, as compared with 14,134 tons for the previous six months, and 106 tons in the half year pre-war period ending April, 1914. Imports of billets, blooms and slabs from the countries named amounted to 27,822 tons during the past six months, as against 16,013 tons in previous half-year, and 24,134 tons for the six months ending April, 1914. Unloadings of plates, bars, angles and rails during the past half-year totalled 2,869 tons, as compared with 12,834 tons for the previous six months, and 13,460 tons for the corresponding period to April, 1914.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The position of things in the Scottish steel trade has shown little alteration over the week, and business is at a very low ebb. The crises in the shipbuilding and engineering trades have certainly played havoc with the steel industry, but the prospect of an early settlement in the shipyards makes for a better outlook. At present there is practically nothing being delivered to the yards, and for that matter to almost any buyers, either at home or abroad, except some small odd parcels. Inquiries are poor for all classes of material. Makers of black sheets are doing very little again, and orders on hand amount to small tonnage. Prices show no change and are as under:—Boiler plates, 14*l.* per ton; ship plates, 10*l.* 10*s.* per ton; sections, 10*l.* per ton; and sheets, 11*l.* 15*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—No change of any kind can be noted in the state of the malleable iron trade of the West of Scotland, and there are very few buyers in evidence. Holding-off is the general order of the day, and little improvement in business is looked for so long as the present labour troubles continue. The basis price for "crown" bars is unchanged at 11*l.* per ton.

Scottish Pig-Iron Trade.—In the local pig-iron trade there is still little doing, but a better tone is noticeable, and it is generally believed that an improved state will come into being very soon. The current output is more than sufficient to meet all demands, but with more inquiry on export account there is likely to be less stocking of iron in the near future, as producers are ready to meet buyers in the matter of price, and thus secure orders to keep their furnaces in blast and prevent the accumulation of stocks. The following may be taken as to-day's rates:—Scottish hematite, 5*l.* 5*s.* per ton, delivered at the steel works; No. 1 foundry iron, 4*l.* 17*s.* 6*d.* per ton, and No. 3 quality, 4*l.* 12*s.* 6*d.* per ton, both ex-makers' yards.

Scottish Shipbuilding.—The Scottish shipbuilding returns for the past month were a record, but not one of the kind which it is pleasant to chronicle. It is doubtful if a worse return was ever made for any month in the history of shipbuilding in modern times. The Clyde figures consist of 1 vessel—a passenger launch—of 25 tons, and that has to be compared with 14 vessels of 26,850 tons for the previous month and 21 vessels of 22,836 tons for April of last year. The falling-off is the direct result of the strike in the shipyards and the lock-out in the engineering trade, and until these are settled no improvement can be looked for. The prospect of work in the yards being begun before long is now brighter, but, as things are at present, there seems little chance of the engineers returning to work in the meantime. The amount of new tonnage on hand is very small, but as soon as shipbuilders are able to offer lower prices for new contracts there is the reasonable possibility that shipowners will again enter the market.

West of Scotland Iron and Steel Institute.—The annual meeting of the West of Scotland Iron and Steel Institute was held in the Royal Technical College, Glasgow, last week, Mr. Andrew Gray presiding. The annual report, which was submitted by the secretary, Mr. Douglas A. McCallum, showed that the membership stood at 602, and that the financial position was satisfactory. The following were elected as office bearers for the ensuing session: President, Mr. E. H. Lewis; vice-presidents, Mr. J. Mitchell, Mr. J. Macfarlane and Mr. R. S. Wilson; hon. treasurer, Mr. Douglas A. M'Callum; members of council, Mr. W. G. Turnbull, Mr. G. Thom, Mr. R. Percival Smith, Mr. R. Crichton, and Mr. G. A. M. Cunningham. A paper entitled "The Constitution of Basic Slag," by Mr. D. N. M'Arthur, B.Sc., and Mr. A. Scott, B.Sc., was read and discussed.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Both the owners and miners have received a disappointment in the news that the general wage rate in South Wales for May is to remain at the minimum of 28 per cent. above the 1915 standard. In view of the improvement that had taken place in selling prices during March, and the fact that the Customs returns showed an increased yield of over 500,000*l.*, as compared with February, it was fully expected that the miners would have been entitled to a small advance in the wage rates. This hope has not been fulfilled, for the audit of the joint accountants show that, though there was a considerable improvement in March, the proceeds, after allowing for the cost of standard wages, other costs and the owners' standard profits, show only sufficient to pay 16·76 per cent. above the standard, whereas the minimum wage is 28 per cent. above the standard. Meanwhile, there has been no appreciable change in the position of the market. Though new inquiries are none too plentiful, most collieries are well stemmed for this month, and in many cases into next month, and therefore are not prepared to modify their prices, which are on the basis of 28*s.* 6*d.* for best Admiralty large and 19*s.* to 20*s.* for best steam smalls.

Small Ship-Repairing Contracts.—Bristol Channel firms have been successful in securing three small ship-repairing contracts in open competition. In the case of the steamer Calcaria which grounded and received bottom damage, the Penarth Pontoon, Slipway and Ship-Repairing Company, Limited, have undertaken to complete the repairs, which necessitate dealing with about 50 plates and fitting a new rudder, in 18 working days. The Hansen Shipbuilding and Ship-Repairing Company, Limited, Bideford, have secured the work of repairing the steamers Swanston and Torquay. The Swanston stranded near Plymouth. She was partially submerged, and had to be salved. It was found that she had sustained bottom damage, which will necessitate dealing with about 20 plates, 15 frames and all the living accommodation. The work is to be done in 25 working days at a cost of 2,400*l.* The Torquay, which also received grounding damage, is to be repaired by the Hansen Company in 19 working days, at a cost of 1,200*l.* Some 15 plates have to be dealt with, also the tank tops, floors and ceilings, besides lifting the rudder and overhauling the engines.

THE STEAM-TURBINE PADDLE TUG ZÜRICH.—The side-paddle steam tug Zürich, which last month made her trial runs on the Rhine between Augst and Basel, was built by the firm of Buss A.G., of Basel, and fitted with steam turbines of the Zoelly type by Escher Wyss and Co., while Fr. Krupp, of Essen, supplied the reduction gearing. The boat measures 65 m. (213 ft.) over all and 8 m. (26 ft.) between the paddle boxes.

NAVY ESTIMATES, 1922–23.—Full details of the proposed naval expenditure for the ensuing financial year are now available to the public, the estimates having been printed and published by H.M. Stationery Office, whence they may be obtained at the price of 15*s.* net. We have already commented on the various items of expenditure in an article published in our issue of March 17 last, on page 330, and have therefore but little to add on this occasion. We note, however, that three new light cruisers—Capetown, Despatch and Diomede—will be completed during 1922–23, as also will be two destroyers, Worcester and Wren; two aircraft carriers, Eagle and Hermes; and two submarines. In addition, work will be continued on four light cruisers, two flotilla leaders, three destroyers, six submarines and one minelayer. As mentioned in the article above referred to, a start will be made late in the year on the two new armoured ships to be laid down in accordance with the terms of the Washington agreement. No other new ships of any class will be commenced during the year, but the aircraft carrier Furious, the battle cruiser Renown and the battleships Royal Sovereign and Royal Oak are being reconstructed, and a number of vessels, including the battleship Emperor of India, the battle cruiser Tiger and the light cruisers Vindictive, Birmingham, Weymouth and Yarmouth are undergoing extensive repairs and alterations. The whole of this reconstruction and repair work will be carried out in H.M. Dockyards.

THE INSTITUTION OF NAVAL ARCHITECTS.—It has been arranged to hold a summer meeting of the Institution of Naval Architects in Paris from July 4 to 8 next, on the invitation of the President of the Association Technique Maritime. A highly influential reception committee is being formed which will include the Minister of Marine, and representatives of the Ministry of Public Works, of the French Navy and of a number of important public authorities and large private firms. The following provisional programme has been arranged:—Tuesday, July 4, at 10 a.m.: Opening meeting to be held in the Amphitheatre of the Sorbonne (University of Paris). His Grace the Duke of Northumberland (President of the Institution) will preside. Papers will be read on the mornings of July 4, 5 and 6, the afternoons being devoted to sightseeing, receptions and visits to works, &c. Tuesday, July 4: Afternoon tea and reception by M. Bertin. Wednesday and Thursday, July 5 and 6: Afternoon receptions by the Minister of Marine; the Municipal Council and the Chamber of Commerce. Wednesday, July 5: Dinner given by the Institution of Naval Architects. Friday, July 7: All-day excursion to Rheims and the devastated areas in that neighbourhood. A luncheon will be given by the Association Technique Maritime. Saturday, July 8: A visit to the shipyards at Havre and/or Caen will be arranged, provided a sufficient number of members express a desire to take this journey. Those doing so can return to England *via* Havre and Southampton. Members intending to take part in the summer meeting are requested to give notice to the secretary not later than May 15.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 5, at 8 p.m., at Caxton Hall. Lecturette, "Casting Under Steam Pressure," by Mr. E. N. Ching (Demonstrations).

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Saturday, May 6, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. Informal Discussion Evening to discuss "Uniflow *v.* Multiple Expansion Steam Engines."

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Monday, May 8, at 7.30 p.m., Joint Meeting with the Bradford Engineering Society. Lecture in the Hall of the Bradford Technical College: Mr. J. W. Dawson, A.M.I.E.E. (Assistant Engineer, Bradford City Tramways), on "Brakes for Tramway and Road Vehicles," illustrated by lantern slides.

THE SURVEYORS' INSTITUTION.—Monday, May 8, in the Lecture Hall of the Institution, when a paper will be read entitled "Agricultural Valuations," by Mr. Robert Cobb, Fellow. The chair will be taken at 8 p.m.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, May 9, at the Royal Society of Arts, John-street, Adelphi, W.C. 2, the following paper will be read: "Kukkersite—The Oil Shale of Esthonia," by Mr. E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S. The chair will be taken at 5.30 p.m. by the president, Professor J. S. S. Brame, F.I.C., F.C.S.

THE INSTITUTION OF BRITISH FOUNDRYMEN: BURNLEY SECTION.—Tuesday evening, May 9, at 7.30 p.m., in the Technical College, Ormerod-road, Burnley. The Annual Meeting. After the Election of Officers there will be an open discussion on a Foundry problem: "The Burning of Castings." Mr. A. Sutcliffe, of Bolton, will open the discussion by giving a short paper on the subject.

THE JUNIOR INSTITUTION OF ENGINEERS.—Wednesday, May 10, at 8 p.m., at Caxton Hall. Paper, "Notes on Hardness," by Mr. R. K. Innes (Durham bursar). Friday, May 12, at 7.30 p.m., at the Institution of Mechanical Engineers, Storey's Gate. Lecture, "Tanks and Chain Track Artillery," by Mr. L. A. Legros, M.Inst.C.E., M.I.Mech.E. (slides and cinematograph films).

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 10, at 8 p.m., "The Design of Repeating Patterns for Decorative Work," by Major Percy A. MacMahon, R.A., Sc.D., LL.D., F.R.S. Sir Charles Carrick Allom will preside.

THE SOCIETY OF TECHNICAL ENGINEERS: SOUTH-EASTERN DISTRICT.—Wednesday, May 10, at 7 p.m., at the Institution of Electrical Engineers, a Lecture will be delivered by Mr. J. F. Crowley, D.Sc., M.I.E.E., &c., on "An Engineering Tour in India." Mr. C. H. Wordingham, M.Inst.C.E., M.I.E.E., &c., &c., in the chair.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, May 10, at 8 p.m., at the Institution of Mechanical Engineers, Storey's Gate, London, when Mr. James Watt will read a paper entitled "Automobile Calculations—Practical Methods for the Designer."

THE OPTICAL SOCIETY.—Thursday, May 11, at 7.30 p.m., at the Imperial College of Science and Technology, when there will be a discussion on "Motor Car Headlights," having special reference to the optical and ophthalmological problems involved.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 12, at 9 p.m., a discourse will be delivered by Mr. H. H. Dale, C.B.E., M.D., F.R.S. The subject is "The Search for Specific Remedies." Afternoon Lectures, at 3 p.m.: Tuesday, May 9, Sir Arthur Keith, M.D., LL.D., F.R.S., M.R.I., Fullerian Professor of Physiology, R.I., on "Anthropological Problems of the British Empire: Series II.—Racial Problems of Africa" (Lecture III); Thursday, May 11, Professor F. Keeble, O.B.E., Sc.D., F.R.S., on "Plant Sensitiveness: (I) To Light"; Saturday, May 13, Professor O. W. Richardson, D.Sc., F.R.S., on "The Disappearing Gap between the X-Ray and Ultraviolet Spectra: (I) Grating Results."

THE WEST BROMWICH ENGINEERING SOCIETY.—Friday, May 12, at 7.30 p.m., at the Technical School, a paper on "Fuels" will be read by Mr. S. Lamb, A.R.S.M. Lantern and special experimental demonstrations. Sir T. Harris Spencer, K.B.E., M.I.Mech.E., will preside.

ELECTRIC COIL IMMERSION HEATER.—A new and attractive form of portable electric immersion heater has been brought out by Messrs. George Nobbs, Limited, of 89, Cleveland street, Fitzroy-square, London, W. 1. It is adapted for household use and for heating small quantities of water or other liquid in jugs, or similar receptacles. The heater is in the form of an open coil, 2 in. in diameter by 2 in. high, and consequently will go into a cup or other small vessel. The coil is made from a nickel-plated and polished tube inside of which the heating element is carried. The coil form has, of course, the advantage of giving a large heating surface so that the heating action is very rapid. The actual heating area is 34 sq. in. The coil is terminated at each end by a straight stem. The two stems lie side by side and carry the incoming wire connections at the top. The coil and stems are made in one piece so that the arrangement is easily kept clean, but the heating element is confined to the coil portion. The heater, which is known as the "Genii" is made either for 100 volts to 120 volts, 200 volts to 220 volts or 230 volts to 250 volts. Nickel-chrome wire is used for the element for high voltage and nickel-copper for low voltage. A pattern of heater is made, with a change-over plug at the top, which can be used on 100-volt to 120-volt circuits or 200-volt to 250-volt circuits.

TRAVELLING GANTRY MULTIPLE DRILLING MACHINE.

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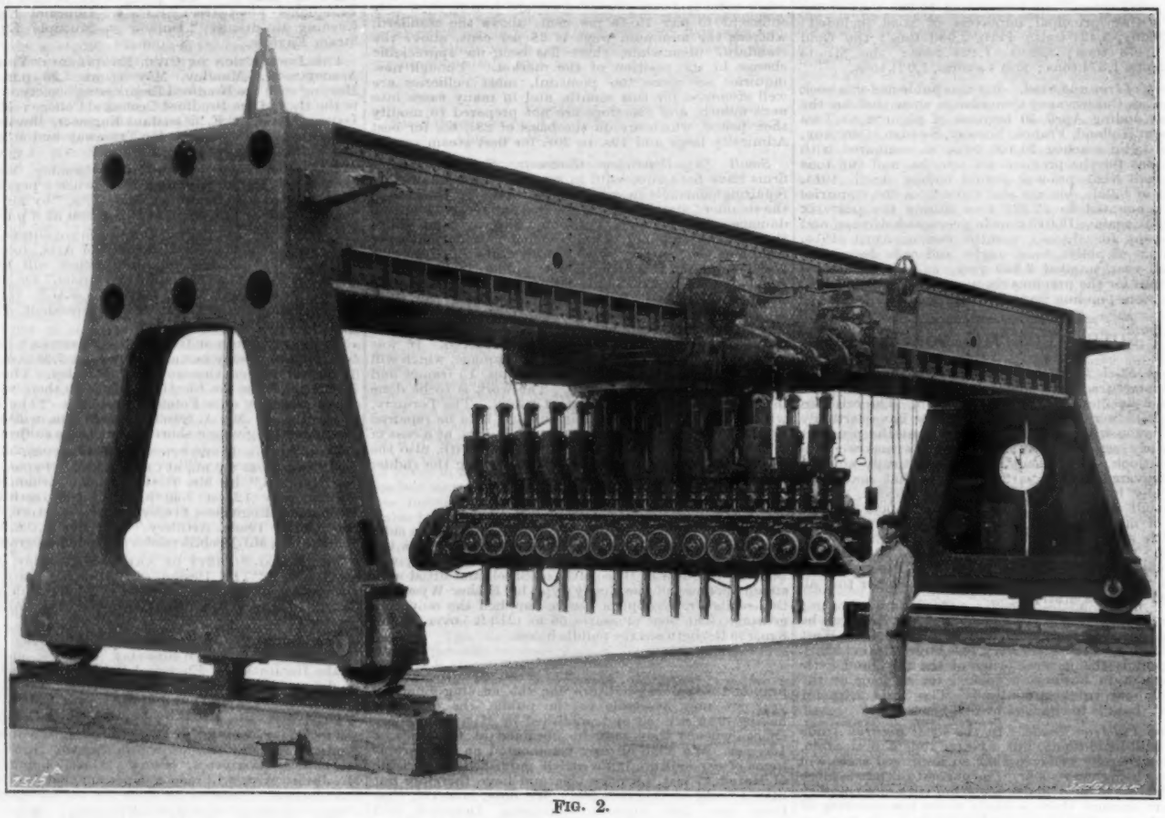

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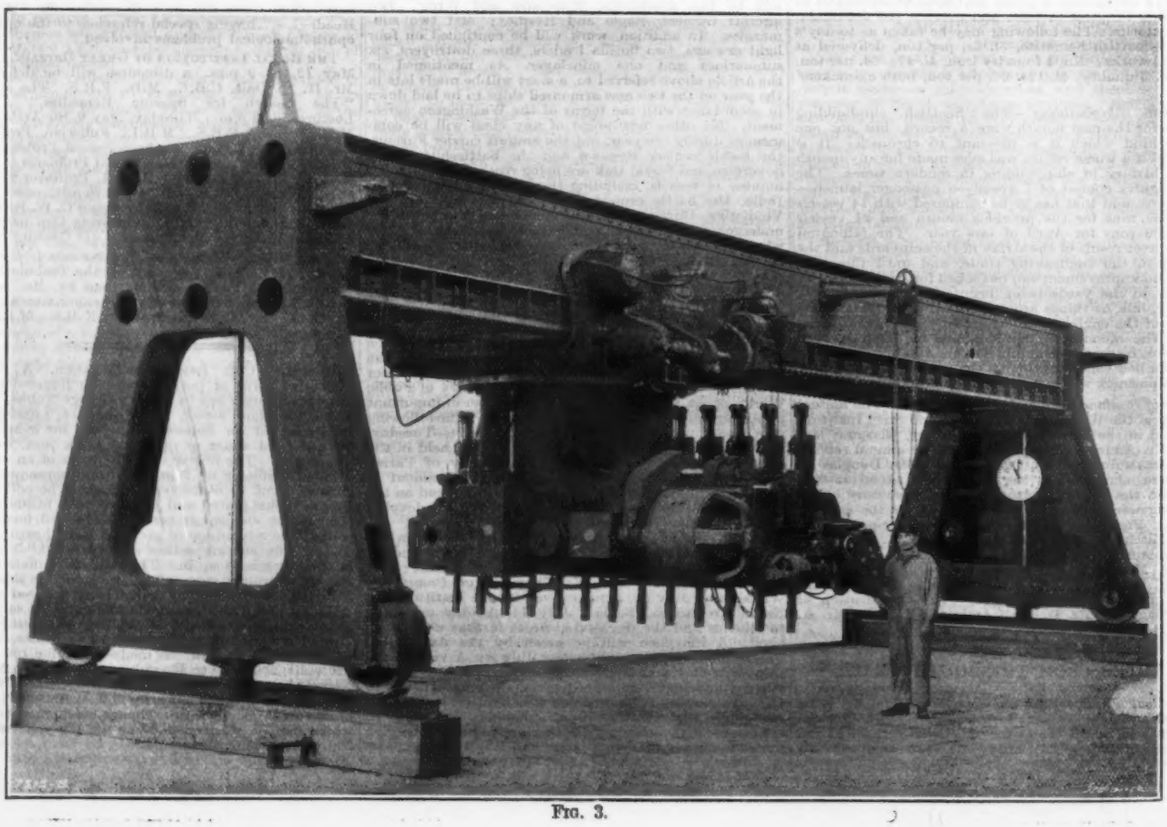

FIG. 3.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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ENGINEERING.

FRIDAY, MAY 5, 1922.

RAILWAY TRANSPORT PROBLEMS.

THERE are few concerns subjected to such frequent and partisan criticism as those whose occupation it is to minister to the needs of the community by transporting passengers and freight. The manufacturer as a rule conducts his business in a factory, more or less withdrawn from the public eye. So long as he keeps on good terms with the unions, or, in the event of a break with them, has a good case to put into the hands of the daily Press, he is immune from outside comment. It is quite the contrary with so-called public services. Thus the management of water supply, electricity, tramway and other undertakings form the subject of criticism, but while the extravagances or shortcomings, or other characteristics in these cases may lead to jokes or jibes, or even scandals, these are of a strictly parochial interest, and the country as a whole takes but little account of them. With the railways it is otherwise. The railways reach practically everywhere; they are used by everybody from childhood upwards. They are indispensable in carrying the workman to his job, the girl clerk to her city occupation, the business man to his office, raw material to the factory, and the product to the warehouse, port or retailer. They contribute more than people are willing to admit to their happiness and recreation, enabling the town dweller to reside in healthier suburbs, and a good portion of the nation to enjoy a complete change for what is often all too short a spell of relaxation from the strain of modern business.

The service thus rendered to all classes makes them so familiar, in a superficial way at least, that everybody appears to consider himself competent to judge whether the railways are efficiently conducted or not. It is an extraordinary thing that transport, than which, when it becomes a matter of working on a big scale, few things are more complicated, and which is a matter for patient and lifelong study, should be thus considered to be capable of reform by anybody and everybody. A trader or manufacturer would be the first to resent gratuitous advice as to how his firm or factory should be run, from the man in the street, or even from a business concern like a railway company. Yet, if the railways search for means of coping with changes of the times, we have the traders and manufacturers publishing their views as to how the railways should be conducted in order to produce dividends with low rates, while the road transport industry certainly has not suffered from over modesty in asserting what they think the railways ought, or ought not, to do—and this in spite of the fact that many who rushed into motor transport at the close of the war are now regretting that they did so without better knowledge.

It is not to be concluded from what we have said that we do not consider improvement possible on the railways. No railway official would be so foolish as to argue that their services were the acme of perfection. Progress is always possible, but knowing their business as they do, and having managed it, till Government interference intervened, in a manner which carried so much confidence that railway stocks were placed among authorised trustee investments, we hold that these companies may be taken to be fairly good, though perhaps not infallible, judges of what can, and what cannot, be done.

It is a relief to turn from some of the memoranda issued by rival partisans to such a careful discussion of some of the problems now facing the railways, as Sir J. A. F. Aspinall placed before his audience when he delivered the 28th James Forrest lecture on Tuesday last at the Institution of Civil Engineers. This lecture, which we commence to reprint on page 569 of this issue, was concerned with a much wider field than railway transport. The few points we shall touch on here, however, will be confined to that subject, and we have no hesitation in saying that we hope Sir John Aspinall's views will carry the weight due to them as coming from one of the most able engineers and managers of which this generation has had the benefit.

Reverting to the question of progress possible on the part of railway companies, we may point out that Sir John Aspinall warned his audience against taking average figures as indication of what the companies were doing. For instance, the average freight train load in this country is only 126 tons, whereas it is known that trains of 1,000 tons and 1,200 tons are in use. With the methods now in vogue at main loading and transhipping points, and the knowledge that such large trains are in service, the average might be expected to show up better. In time no doubt it will improve as it has done in the United States. There, in 30 years, the average train load has increased from about 179 tons to 675 tons, or by nearly 500 tons. At the present time the average for some areas of that country is as high as 877 tons, but when these figures are compared with the usual maximum load for the country our proportion of average to maximum of 1,200 tons, is much the same—with this exception—that in the special area referred to the average is raised considerably by traffic hauled to tide-water in trains of 12,000-16,000 tons. Such traffic as this, however, involves a large amount of empty mileage in returning special stock, which it is one of the railways endeavours in the ordinary way to avoid. There is nearly always, however, a balance of traffic in one direction, and different classes of traffic require different types of accommodation, so that it is impossible to avoid a large amount of empty mileage; yet it is desirable to keep, generally speaking, as far as possible from the extravagance of the organisation adopted by the White King in Alice through the Looking Glass, of "one to come and one to go"; and "one to fetch and one to carry."

It may be pointed out that the abolition of the private wagon would give the railways much additional freedom in this matter of wagon working. There are about 600,000 private wagons in the country distributed among nearly 6,500 owners. All these have to be shunted out specially and returned as ordered. In his lecture on Tuesday, Sir John Aspinall calculated that the shunting out of these wagons ran into an expense of something like £14,000,000 per annum—a sum which is equivalent to about 20 per cent. of the total locomotive expenditure for running, repairs and renewals, for the country. The ownership of these wagons by the railways would, as Sir John states, eliminate a very large proportion of this shunting expenditure, and it is to be hoped that the Ministry of Transport will exercise the powers it possesses in the direction of encouraging railway instead of private ownership of such stock.

This, of course, is one of the matters which grouping

should help to bring about. At present the companies are occupied with organising under the amalgamation schemes. By the end of the year this amalgamation is to be complete, and then there will be more time for working out improved methods of operation. Doubtless, many such, hitherto without the range of practical politics, will then be found to be less difficult of attainment than formerly. We may, for instance, refer to the large capacity wagon, mentioned by Sir John Aspinall in his address. We believe that in South Africa when it was decided to adopt the large wagon as standard for coal traffic, notice was given to those concerned that, after a certain date, their facilities would have to be such as to make it possible for these to be not only employed but also released quickly. The result was the introduction of the 40-ton capacity hopper car. Supposing similar action were taken by the four large groups in England, it would soon become practicable to introduce the large car for specific forms of traffic in this country. Taking export coal, Sir John Aspinall estimates the savings which would accrue in this way to be between 1*s.* and 2*s.* per ton, which he concludes on this traffic alone would reach £5,750,000 per annum. If this sum be capitalised it would represent a substantial amount, with which the expense of £3,000,000 for the conversion of the coal-handling appliances at the ports, to take the larger wagons, would be comparatively small.

Additional to this traffic, is some 13,000,000 tons of locomotive coal traffic, most of which is delivered in large enough quantities to warrant the use of large cars, and the structural and other alterations required to permit of their use. In this matter it is known the railways have been conservative, and when labour was cheap they were undoubtedly right in their policy, as careful investigation into any actual case would show. However, since 1914 this economic aspect of mechanical appliances has undergone a complete change. Before the war the high development of coal handling at ports and locomotive terminals in America had been almost wholly due to the price of labour. We are to-day much where America stood then, and with labour now approximating to more than one-half the total railway expenditure (including interest) compared with less than one-third before the war, mechanical methods assume an altogether different aspect which the companies already show signs of recognising.

ECONOMIC CONDITIONS IN GERMANY.

THE publications of H.M. Trade Commissioners and Commercial Diplomatic Officers on the commercial and financial conditions in various countries supply a mass of well-digested and approximately accurate information, but the recent issue of the report on the economic condition in Germany up to March, 1922, is of particular value, as it furnishes data for determining the vexed question of the capacity of that country to meet the treaty obligations, into which it has entered with the allies for the payment of reparations and indemnities. Is Germany tottering under the oppressive weight she has to carry, and is she exhausted by the unequal fight she has to maintain against adverse circumstances? Judged by whatever criterion is selected, it would appear that the demand for extreme mitigation is misplaced and the outcry for debt cancellation unwarranted. The increasing number of joint stock companies floated is a sign of intense commercial and industrial activity, while the readiness with which money is obtainable without any difficulty in large quantities demonstrates that the nation cannot be suffering either from an unduly heavy burden of taxation, or from the inconvenience occasioned by the remission of specie and valuables abroad. The factories are working at full time, and the number of unemployed is less than in the years before the war. The number of unemployed on January 1, 1922, was only 210,000, about half the number a year previously, and this in a country whose population amounts to 60,000,000, while with our population of 43,000,000 the number of unemployed is approximately ten times as great. The number of bankruptcies in 1921 showed an increase over those of 1920, but compared with pre-war times the number is insignificant. In 1913, the total bankruptcies for the year amounted to 9,725, but in 1921 there were only 2,975 defaulters. We trust we are not doing the German an injustice if we suggest that he is sufficiently acute in emphasising the difficulties of the country, but he does not exhibit the same adroitness in calling attention to the many advantages he enjoys, and the great improvements which have taken place since the end of the war, which demonstrate the inherent strength of his fiscal and industrial position.

In magnifying her distressful condition Germany makes the most of the depreciation of the mark, a fact that is patent to all, but its causes are very imperfectly understood. Whether she is entitled to our sympathy and commiseration on the grounds put forward may be doubted. Indeed, it is not difficult to perceive that there are compensations, and these compensations may outweigh the obvious disadvantage of a large issue of paper currency. Whatever the disadvantages may be they are largely exaggerated, for on December 31, 1921, the gold cover amounted roughly to 1,000,000,000 marks, or 50,000,000*l.* sterling; a very reasonable proportion to the true value of the note circulation, and one that suggests that the excessive depreciation has been fostered by selfish and artificial means. Actually the financial position is not one that warrants the severe decline we have witnessed, and, moreover, an equal depreciation of the mark has not taken place in its internal value and home circulation. It is the knowledge of the internal stability of the country contrasted with its strained condition as indicated by the depreciated currency that has provoked the enormous mark speculation on all the money markets of the world, exercising a baneful and depressing effect, but one that has convinced a powerful section of the German community that a low rate of exchange is a valuable commercial weapon not lightly to be thrown aside.

If the depreciation of the mark has been effected or accelerated by fictitious and unreal causes, it has nevertheless been fraught with very considerable benefits, the more considerable probably since these are so energetically repudiated by the Germans themselves. By her organised methods of commerce and her trained army of industrials, Germany, aided by the low mark, has been enabled to attract to herself a large part of the world's trade in manufactured goods, and in time of general depression such as the present, this factor has allowed resuscitation to make giant strides. The low mark has been the main cause of the recovery of her overseas markets and supplied new outlets. It has enabled her to proceed apace with the reconstruction of her mercantile marine, as German ships, which are paid for in paper marks, can earn freights paid in gold. Also, it is the low value of the mark which has saved Germany from the crushing burden of unemployment under which the remainder of the world has suffered. This is fairly obvious, but the compilers of the report, Messrs. Thelwall and Kavanagh, point out, what has not been so generally appreciated, that it is the low mark which has made it easy for the German manufacturer and importer to re-establish foreign balances. "Had the mark not been low, they could not have sold their goods and obtained foreign currency in the ordinary way of business. Now they have been able to do so, and the great anxiety of two years ago concerning the supply of raw material has thereby been removed." Whether the future has been discounted and this time of prosperity will have to be paid for later, time only can show. The stabilisation of the mark may bring about very serious crises, and if, as is not improbable, the mark is left to adjust itself, the rise that will follow the establishment of more amicable relations with the allies will entail a period of difficulty greater than any Germany has encountered since 1919. It is, however, equally probable that deflation will be so slow and gradual that no abrupt disturbance will have to be faced. Time is fighting on the side of Germany.

The scheme of taxation is as perplexing as that of finance. Without any hesitation, it is asserted that the revenue from taxation does not produce its calculated amount, for the large industrial interests are able to defeat the Government plans. The country is richer and more prosperous than the revenue returns would indicate. Luxury and self-indulgence are rife, and there is no evidence of a struggle to make both ends meet, which would be apparent if the taxes were burdensome. Sympathy or forbearance can hardly be extended to a country which is making merely fictitious efforts to redeem its obligations. The working man and the official with fixed income are taxed out of proportion to the manufacturer, the banker, or the speculator. The direct taxes paid by the lower and middle classes should be reduced, and the wealthy be compelled to pay a more adequate share then they have done hitherto. It seems only prudent and just that this latter class should be made to declare their foreign holdings, which there is every reason to believe are considerable. When the Government proposed to annex some portion of the foreign dividends, the wealthy classes took alarm and proposed to assist the State by placing a portion of their foreign holdings and credit at the disposal of the Government for the payment of reparation instalments, in return for which it was claimed that a portion of the future taxation should be remitted. To a foreigner accustomed to yield implicit obedience to the ruling authorities, the manner in which the proposal was made seems offensive. After weeks of wrangling negotiations, the industrialists actually made their offer conditional upon the transfer of the railways from the State to themselves. The Government indignantly refused to entertain such a proposal, which would be equivalent to paying for something already due to it. These discussions seem to have come to an end in view of the decision to raise a forced loan in gold. But the picture disclosed is not inviting, for it evidences a Government that does not govern and the existence of a party sufficiently powerful to hector the ruling authority and to maintain it in power so long as it obeys the behests of a clique. The existence of a powerful and selfish organisation, representative of the interests of a class, does not augur happily for the general welfare of the country, and from the point of view here considered is particularly unfortunate, as it makes foreigners suspicious of the genuineness of the declared assertions of the German authorities, that they are honestly unable to meet the obligations they have contracted.

If the taxes levied in 1921 had been paid, the German national income would have been taxed to the extent of 43 per cent., which would apparently yield a large and satisfactory sum. From the tables collected in an appendix it is shown that the total receipts from taxes in 1922 are calculated to amount approximately to 95,000,000,000 (paper) marks, a sum by no means so large as the imposing array of cyphers suggests. The amount recoverable per head is only 1,583·8 marks. Here may be noted the effect of the perplexing difference between the value of the internal and external mark. At the present rate of exchange, say 1,200, this means the payment of only 25*s.* per head, and a total revenue of 80,000,000*l.* sterling. The investment of a very moderate amount of capital in foreign securities would enable the wealthy to discharge their fiscal obligations to the State, demonstrating the privilege enjoyed by the richer classes, and explaining their unwillingness to disclose the extent of their investments. A list of new taxes is given, but as these proposals have not quitted the Committee stage and their final form is quite uncertain, there is little interest in discussing them. It may, however, be said that the income tax shows a reduction, slight in the case of small, and large in the case of very large, incomes, but to the man of moderate income the tax is approximately halved.

A very satisfactory gauge of the prosperity of the country is furnished by the scarcity of unemployment, evidencing the intense industrial activity prevailing, and at the same time saving that mass of expenditure which any system of doles necessarily entails. A census taken on a day in December shows that the great centre of unemployment is confined to Berlin, no less than one-half of the total of the country hovering round the city and its suburbs, where no doubt it makes its voice heard. It is not uninstructive to note that the amount of unemployment was greatest when the mark stood highest, demonstrating the beneficial effect which a low rate of exchange exercises on the condition of the industrial market. But Germany contrives to make capital out of unemployment. Between January, 1920, and October, 1921, 850,000,000 marks were spent on productive unemployment

relief, providing work for 390,000 unemployed, during 100 days. It is estimated that the work done was worth at least M. 2·8 milliards, but independent of this loose calculation, it can be conclusively shown that 966,000,000 marks were saved directly and indirectly, in unemployment doles, by an expenditure of 850,000,000 marks on productive unemployment relief. Another proof of the contented and favourable condition of the people is instanced by the freedom from strikes. In making a comparison with our less favourable lot, it must be remembered that the population of Germany is half as great again as that of Great Britain, yet the number of strikes here exceeded those in Germany in the ratio of 2·4 : 1. The actual numbers are as follows :—

	Germany.	Great Britain.
Number of persons on strike (1921)...	772,891	1,873,950
Number of strike days lost ...	11,608,129	81,211,900
Average length of strike, in days ...	15	43·3

Wages as paid in fluctuating marks do not afford an effective criterion without taking into account the cost of living, and then the number of variables become very great, but it is noteworthy that while a great increase in the wages of both skilled and unskilled operatives is observable, the latter have advanced proportionately more than the higher class, or there is a tendency to level up the remuneration paid to all workers. Generally, the wages of skilled workmen throughout Germany increased 16·7 times, from 1913 to 1921, and 3·6 times from 1919 to 1921. For the unskilled, similar figures are respectively 20·4 and 3·8. Between 1914 and 1921, foodstuffs advanced 12½ times, and by the end of 1921 had further increased to 21 times. The rise is rapid in the most recent months, and this fact is confirmed by an examination of the prices of the chief articles of consumption. In a table enumerating these articles, the average increase is 25 times the 1914 price.

The foreign trade of the country so far as it can be gauged from the figures given in many well-arranged tables appears to be as satisfactory as the internal condition. No values for the imports of 1920 are available, and where figures are quoted, the comparison is rendered very uncertain, owing to the pre-war values being given in gold marks, while in the values for recent years, the unstable rate of exchange introduces a very disturbing factor in converting the paper mark into sterling. Using the unit of metric tons the ambiguity is much less, and the following comparison can be made :—

	Imports. Metric Tons.	Exports. Metric Tons.
1913	72,832,781	73,713,532
1920	18,836,626	19,809,608
1921 (eight months)	17,550,800	13,720,989

The average rate of exchange for the year (405·33 to the £) is of little use now, but the conclusion may be drawn that the estimated export of 20·6 million metric tons has brought a smaller return in sterling equivalent than 19·8 million metric tons in 1920, when the mark was much higher. An analysis of the imports shows that food-stuffs and raw materials account for about three-quarters of the total German imports, approximately the same proportion that ruled before the war, but although the import of raw material in many cases still remains well below that of 1913, in not a few important articles, as in textile raw material, the figures for 1913 are exceeded. The quantities for cotton, wool and copper are instanced, the latter only showing a decline :—

	Cotton. Metric Tons.	Wool. Metric Tons.	Copper. Metric Tons.
August, 1913 ...	29,800	8,400	18,000
July, 1921	35,100	10,900	10,700
August, 1921 ...	52,400	14,700	8,200

The Board of Trade figures being given in paper marks, at various rates of exchange, do not disclose very clearly the true position of the trade of the United Kingdom with Germany, but the conclusion is derived, that Great Britain furnished 11·5 per cent. of German imports in 1913 and 13·8 per cent. of the estimated total for 1921, while absorbing 16·2 per cent. of German export trade and 8·3 per cent. of the estimated total in the year 1921.

The report discusses in detail the trade with individual countries, and also the conditions prevailing in special trades as the Iron and Steel, the Coal industry, Shipping and Shipbuilding, &c., but reference must be made to the report itself for statistics and results. Since the iron and steel and allied trades represent the most important basic industry, we may extract a few details from the contribution by Mr. Kavanagh to indicate the line of investigation adopted. In the following table, showing the amount of imports and exports from May to December, 1921, the effect of the fluctuation of the mark on the relative activity can be easily traced :—

1921.	Imports.		Exports.	
	Ironwork of All Kinds.	Machinery.	Ironwork of All Kinds.	Machinery.
	metric tons.	metric tons.	metric tons.	metric tons.
May	43,880	189	129,847	25,096
June	47,013	256	162,297	36,719
July	55,104	283	177,773	39,792
August	70,008	315	240,071	29,036
September ..	106,519	847	225,331	28,757
October ..	146,695	1,039	246,115	26,626
November ..	94,222	339	234,249	27,989
December ..	90,486	1,006	216,264	37,484

The relative decline towards the end of the year is due to the comparative stabilisation of exchange. Prices are assuming a more proportionate level, but a period is again being reached where the difference between inland and world market prices shows a wide margin, which will only be diminished when the existing stocks of iron and steel manufactured from raw materials previously purchased abroad are consumed, and the increased prices of coal, raw materials, food-stuffs, and labour have their contributory effects. Further falls in exchange will produce a flood of new activity, but while stability is insecure and the industry enjoys indirect subsidies in the way of cheap labour, coal power and transport, Germany will continue to be a chief source of supply for manufactured goods. There is now no lack of orders on the market: works are fully committed for months to come, and only accept new orders free of engagements as to prices. The position is not too well defined and not too secure, but the industry is working throughout its branches at high pressure, and as a consequence dividends are being paid equal in amount to those paid in boom years, reserves are being accumulated, and in many cases stocks and plants are being rapidly written off. All the signs of prosperity are present, and strikes and industrial unrest in England, by deflecting a large volume of trade abroad, have contributed in no inconsiderable degree to the fortunate position in which Germany finds herself.

A careful perusal of this report will show that in whatever distress the Government is involved, and however ingeniously these difficulties are exploited on political grounds, and to escape the payment of reparations, there is abundant evidence of commercial and industrial activity in the country. The losses of territory, partial or complete, in Lorraine, the Saar Basin, Luxembourg and Upper Silesia, due to the Treaty of Peace, have had but little effect, and if the taxes proposed are collected with rigour Germany can remove the obstacles to a financial settlement, whose delay operated not only to the detriment of that country, but of all others. Germany benefits by the low rate of exchange, affording an easy sale for her goods and consequent employment of her people, and apparently there is no reason why this state of things should not last, for the paper mark and the printing press satisfy internal needs, and she sells the produce of her factories for gold. The path of inflation may have many pitfalls, but they are well concealed, and the intelligence and industry of her people are capable of bridging the yawning gaps that would prove dangerous to a less organised and competent nation.

PHYSICS AND ENGINEERING SCIENCE.

THE Institute of Physics, inaugurated a year ago in the lecture hall of the Institution of Civil Engineers, listened on April 26, in the same place, to the first of a series of lectures, arranged by the Institute, on "Physics in Industry." The lecturer was Professor Archibald Barr, LL.D., D.Sc., his subject "Physics and Engineering Science," and the chair was occupied by the Right Hon. H. A. L. Fisher, Minister for Education, whom the president of the Institute, Sir J. J. Thomson, introduced. Mr. W. B. Worthington welcomed the Institute as the president of the Institution. All the speakers pleaded for co-operation between the adherents of the two sciences, and if Professor Barr took in his arguments the standpoint of the civil engineer, rather than that of the physicist, our readers will hardly quarrel with him.

Commenting, in the first instance, on the broad aspects of the application of physical science in industries in general, Professor Barr remarked that the professor of applied science stood in relation to the physicist on the one hand, and the practitioner on the other, in the position of a go-between or interpreter. He ought to know, in regard to his particular section at least, the points of contact and the divergencies between their fields of activity and ought to be able to assist in the mapping-out and construction of lines of intercommunication. But after fifty years of study and teaching, and more than fifty years of contact with mechanical engineering practice, Professor Barr did not find it easy to arrange his impressions and opinions according to any very definite system. There was no need to re-open the old discussion on "the relative value of theory and practice" in the arts of construction and production. The relative values of knowledge gained in the study of pure science and knowledge gained through long experience in the practice of a particular art could not be discussed in general terms; but we had to assign full values to the mental equipments derived from the two sciences. There was still some misunderstanding as to the manner and extent to which the results of investigations in pure science could rapidly be applied in the conduct of an industry. Though physicists knew something of industrial methods, and many practical men knew little of the latest developments of investigation and speculation, practitioners in the arts in general seemed to have sounder views regarding the aims of men of science than the pure physicist had on the conditions and limitations of industrial processes—a very true and apposite remark.

Physicists should not be impatient to see their laboratory results adopted in industry. A very beneficial departure in one industry might have far-reaching influences on others. When Swan had shown his first electric lamp at the Glasgow British Association meeting of 1876, a well-known physicist had assured Professor Barr that every house in Glasgow would be supplied with the new illuminant by the next winter. After 46 years the number of electricity-lighted houses there was still only of the order of 15 per cent. of the whole. Apart from the labour involved in innovations, vested interests had to be considered if we were not to bring about an overturn of the whole system of society. But taking a narrower view and looking only at the problem as it affected one producer, "the first and, in the broadest significance of the term, the only question must be, Will it pay? That may seem a very sordid view to take, but a little consideration will, I think, justify it." In its broadest significance the question meant, whether it would be to the best interests of humanity for this particular producer to introduce a new process or product, and in its narrowest significance, whether it would pay him or his shareholders. A great overturn might result from a trifling change in a product already in use; a very minute improvement, *e.g.*, in the cap of electric light bulbs might put the firm introducing it out of the market. It was often advisable to wait until several improvements could simultaneously be adopted in a larger development. If physicists were to discover an economical method of producing electricity direct from coal or from radium, it would probably be necessary to take political action to prevent precipitate industrial application in order to avert a civil revolution.

The application of a legislative brake may hardly seem to be required. But Professor Barr rightly pointed to the consequent risk, the scrapping of existing plant and the overturn in the organisation of experienced staff and skilled operatives.

The producer might lose, not only time and capital, but his hold on the market against less enterprising or more cautious competitors. Patent laws afforded only a limited protection, and industrial suicide of enlightened men was not in the best interests of society. Industry was an organism in delicate adjustment with its environment; we had to be careful not to destroy the balance, "Knowledge, like timber, should not be used till it is seasoned."

Passing to his special subject, the relation of physics to engineering science, more particularly to mechanical engineering, Professor Barr noted that the articles of association of the Institute of Physics wisely refrained from giving any other definition of physics and physicists than that implied that physics was the science professed or applied by physicists. In his address at the inauguration meeting Sir Joseph Thomson had included chemistry in the domain of physics. Engineering science, Professor Barr said, embraced all branches of applied physics having bearings on the professional or industrial work of the engineer. Some physicists still held that there was no place for engineering science as a distinct subject in any educational system; that the study of mathematics and physics offered sufficient systematic training for engineers, that there was indeed no science, properly so called, of engineering other than pure physics. Without wishing to discuss these terms Professor Barr maintained that the engineering chairs of our universities had justified their existence for more than eighty years. The teaching there was not purely, nor indeed, mostly "technical." An engineering school of university status was, in fact, not so technical as a medical school. Questioned afterwards by the chairman, whether he wished to make the university course of engineering more technical, Professor Barr replied "certainly not"—and in that again physicists and engineers will agree.

If physics contained all that was known of the properties of matter and the transformation of energy, Professor Barr continued, engineering was, of course, a branch of physics. But when we considered, not the fundamental laws and phenomena with which they dealt, but the aims and functions of the physicists and the natural philosopher, on the one hand, and of the engineer on the other, there were marked differences in the respective attitudes. The problems of the engineer were in their nature almost infinitely more complex than those of the physical investigator. To elucidate his meaning Professor Barr referred to the complexity of the problems of the mechanical structure of plants and animals, wonderful apart altogether from the functions of volition, nutrition and reproduction, and to the adaptation of the animal structure to its environments. The reverse problem, of devising that structure, would be a vastly more complex one. The problems that the engineer had to deal with were of that nature, though fortunately vastly less complex. Yet we read in Bacon, "new inventions are as it were new erections and imitations of God's own works." These new erections were subject to the same mechanical laws as applied in the world of Nature. The actual structures of animals and plants were the result of a long course of development. Could we hope to produce new erections by any more direct process?

Could the engineer in the design of structures or machines follow a systematic course, proceeding from first principles, step by step, as in a mathematical problem? The answer must at once be in the negative. A suitable design for any type of structure must be the result of a long process of evolution. Could the laws of physics directly be applied at various stages? If an engineer had to design a crane to lift a load of one ton under specified conditions, he could not put those data into a formula automatically to grind out the result. He had tentatively first to settle upon the type of crane mainly by relying upon experience. Suppose he decided that a jib crane would best suit the conditions. He had now to estimate the greatest forces that would come to act on the chain hook. The load would not always be lifted with the care that a physicist would take in experimenting on the effect of a load of 1 ton hanging from the hook. The engineer would perhaps, tentatively at least, come to the conclusion that he would require to assume that a force of two tons would sometimes come to act on the hook. He had a skeleton design and proceeded to calculate the stresses in the ties, struts, shafts, &c. That could be done fairly accurately by the aid of elementary mechanics and mathematics.

The selection of the materials was in part involved in fixing on the general design, and he proceeded to determine suitable dimensions for the various parts. This again could be done by the application of simple formulæ, if we assumed that these formulæ were reliable, and that the materials would really bear the maximum unital stress assumed. But the formulæ were far from true, and the stresses that a material could permanently bear were not known under any but the very simplest conditions. Only in very recent years had due attention been given to the distribution of stress over various interfaces in any structural part that had any kind of discontinuity of form, and to the effect of complex stress in producing failure. Perhaps physicists and engineers were both to blame; but nobody could at present calculate with any approach to precision, except in the very simplest cases, the unital stresses produced in a structural part by a given system of external forces or the strength of the material to bear these stresses. Meanwhile the engineer had to make allowances. He divided the accepted strength of the material to bear the stress, he believed to act, by a "factor of safety" of five or more, and he assigned such sectional dimensions to the part as he believed would bring the unital stress within the limits fixed upon—no doubt, a very unscientific process, but as good, perhaps, as any available if he were to come to a decision within a reasonable time. In the case of ductile material at any rate, the engineer was not directly concerned with the ultimate strength on which he based his calculations. Long before a chain or a tie would fracture under direct pull, it would have stretched so much as to fail in its proper duty. Something like one-half of the so-called "factor of safety" was really a correction for a wrong mode of procedure, and the rest an allowance for imperfection of the data and errors in the formulæ.

There were, moreover, other important considerations. The engineer had to bear in mind how each part had to be prepared. The mode of preparation would affect not only the cost, but the strength of the product, and as he had not time to go into all the complex physical questions involved, he allowed for his ignorance of facts as for their uncertainty, by his "factor of safety." Thus a systematic course of procedure in design seemed to be excluded. Professor Barr feared that physicists might think that he had banished the engineer from the realms of scientific light and leading. But he had also attempted to show that in the design of a structure, however simple, the knowledge acquired through experience had constantly to be appealed to, and that knowledge might be worthy to rank as scientific. A sheet of glass could easily be broken along the line that the diamond had cut, and an axle was most liable to fracture at a shoulder. To an uninstructed practical man these items of experience had little connection; the observant engineer would perceive some connection and he would account, qualitatively at least, for the phenomena. The results of investigations conducted in scientific manner would then add definite quantitative data, and by strict reasoning the science could be advanced from the natural history stage to the natural philosophy stage. But the science was still an engineering science, in so far as it dealt with the special needs of the practical man.

There was a great contrast between the methods by which progress was achieved in pure physics and in engineering practice. In pure science progress was made by experiments conducted under definitely specified conditions and by mathematical processes founded upon purified and idealised data. Professor Barr referred to Clark Maxwell's paper on "General Considerations concerning Scientific Apparatus," and quoted Maxwell's statement: "In designing an experiment the agents and phenomena to be studied are marked off from all others and regarded as the field of investigation. All agents and phenomena not included within the field are called disturbing agents, and their effects, Disturbances; and the experiment must be so arranged that the effects of disturbing agents on the phenomena to be investigated shall be as small as possible." That was necessary to reach definite specifiable results. The mathematician had further to simplify these results to bring them within the range of mathematical expression. The engineer then had to take these idealised results, but he had to bring the disturbing agents in again, and he had to deal with countless agents where the formulæ considered only one agent, or a simple group of agents.

Physicists, Professor Barr submitted, often criticised engineers unduly for their departure from true scientific principles in their general designs. He followed this up with special reference to redundancy of constraint. That redundancy involved unknowable reactions between parts of machines or structures, a reaction that could be only determined by almost interminable calculations after the structure had been fully designed, and should therefore be avoided as far as possible. But other considerations might make it imperative to depart from a construction which narrower views would indicate to be desirable. Thus, Kelvin's support for instruments consisting of three feet combined with a hole, slot and plane, would not do for cranes, nor would three feet with a single slot and plane guidance suffice for the table of a planing machine. The adopted design of the Forth Bridge had been criticised as involving redundancy of constraint both as regards the framework and the supports. Baker's original design showed less redundancy, but was altered from consideration of facilities in erection. In the Quebec Bridge the design was less redundant and the stresses were more determinable. But the Quebec Bridge did not reach complete erection, and without inquiring into the contributory causes of the Quebec disaster, Professor Barr stated, it could be said that experienced engineers had failed to erect a bridge that would avoid some of the Forth Bridge features supposed not to be in accord with true principles. In a redundant frame structure the weaker part would usually be the more yielding, and yielding it would shunt a greater share of the duty into the less resisting, because stronger, line of resistance. If it were not for that compensation, many safe constructions would be quite unsafe and would fail long before they had a "general flavour of mild decay," in the words of the Deacon of Oliver Wendell Holmes's well-known poem.

Mathematical methods were not yet available even for many engineering problems in which the conditions could be accurately set out, and were simple from the physical point of view. Thus the distribution of stress in a cylindrical rod of homogeneous and isotropic material, having parts of different diameters connected by a transition part of specified forms, subjected to direct pull, seemed still to be beyond the power of the mathematical investigator, and, in spite of Coker's beautiful work, also of experimental determination. The engineer had that problem constantly before him in the much more complex cases of materials, by no means homogeneous and isotropic. Again, the flow of water through an orifice in a flat plat could not accurately be analysed. The usual theoretical treatment should not be taught, Professor Barr considered. Engineering science could absorb all the results of physical investigations on the various properties of materials, but those results had to be compounded with much that could only be revealed by practice on the large scale and of the special nature of the subject to be dealt with. The relative importance of the facts as bearing upon practice would leave a place for engineering science as a separate body of knowledge, in which pure science was the leaven, not the lump. Moreover, the facts and principles that constituted engineering science should be ready at hand. The physiologist might take his time and consult all available authorities. The physician must have his knowledge available to prescribe for the patient. Pure science was an invaluable servant to the engineer if it assisted him in setting his house in order and served him in a new activity; but it was a bad master if it induced him to undervalue his inheritance from the accumulated results of the labours of his predecessors.

In a sense, then, though certainly not to an undue

degree, Professor Barr stood up for the old trial and error method, and neither Mr. Fisher nor Sir J. J. Thomson dissented. The Minister for Education remarked that they were accustomed to the method, with a great deal of error, "in another place." Sir Joseph considered the properly-controlled trial and error method to be wonderful. Our eyes and ears worked by that method; the perfection of the violin owed little to acoustics. But the method took a long time; trials were apt to go wrong, and science, though it failed us in many problems, had done a great deal. Physicists, Sir Joseph added with respect to hasty innovations, also understood that we could not accelerate mass without straining it.

NOTES.

The Manufacture of Explosives.

The report to the Home Office on the working of the Explosives Act during the past year states that a new Order in Council was issued last July, making it permissible to manufacture liquid air explosives at or near the site at which they are to be used. As yet, however, no advantage has been taken of this relaxation of the regulations, which were originally designed to secure safety with the conventional type of explosive. One "factory" was established during the year for the preparation of a single charge of nitroglycerine, which was used for "shooting" an oil well. As in previous years accidents have been far more frequent in the use than in the manufacture of explosives. Owing largely to the coal strike there were, however, far fewer accidents with explosives than is usual. Only 54 accidents occurred in the manufacture and 205 in use, the total number of fatalities being 35. In 1913, which may, perhaps, be considered the last normal year, there were 86 accidents in the manufacture and 403 in the use of explosives, 66 people losing their lives. There were during the year several cases of theft of explosives, and one case of malicious injury (attributed to private spite), in which a store containing 510 lb. of gunpowder and 785 lb. of gelignite, was blown up. Reference is made in the report to the explosion at the works of the Badische Anilin und soda Fabrik, Oppau, near Mannheim, which is stated to be the greatest on record. Some 600 persons were killed and 400 to 500 injured. The crater formed measured 135 metres in diameter and 35 metres deep. The explosion took place in a silo containing 4,500 tons of a double salt of ammonium nitrate and ammonium sulphate, which was being loosened by blasting. Many thousand shots are said to have been fired in this work without accident, but it is thought nevertheless that this blasting was responsible for the explosion.

Corrosion of Metals.

In a paper read before the North-East Coast Institution of Engineers and Shipbuilders, on the 28th ult., Mr. A. Pickworth, M.Sc., stated that corrosion of a ship's structure was more serious in the vicinity of the boiler room tanks than elsewhere. Such tanks, whether used for ballast or for the carriage of feed water were never really empty and dry, and were, moreover, subject to great heat from the boilers. The first signs of marked corrosion appeared round the edges of the punched manholes and limber holes in the floors and intercostals, where the cold-worked metal was more electro-positive than the normal. The wasting away of the material here was further accentuated by the erosive action of the water, as it washed to and fro' when the tanks were only half full. The rusting was worst at the dampest and hottest part of the tank top, and wherever there was any persistent leakage or drip. In the United States Navy the deterioration in boiler room tanks was such that the inner bottoms had to be patched after four years' service, and in one case, after ten years' service, it was necessary to spend 150,000*l.* for the repairs to the structural work of a battleship. All the registration societies accordingly required an allowance for corrosion in fixing the thickness of the parts in machinery spaces. In the engine-room the corrosion was worst underneath the engine and below the condenser. Bunkers also often suffered from serious corrosion particularly at the lower parts, where a mixture of small coal and mud collected, which was rarely removed except at special survey. Corrosion was also common under side lights, so that it was the rule to require the removal of all woodwork here when a complete examination was to be made. Externally the shell plating suffered most between wind and water, and corrosion was also common in the neighbourhood of bronze propellers. To protect the metal work here the Cumberland Electrolytic system was being tried. On this system a counter electromotive force of about 10 volts was generated by means of a small dynamo. The anodes used were of iron, and were designed to last eighteen months to two years. In concluding his paper, Mr. Rickworth said that the late chief engineer to the London and North-Western Railway Company had declared that there was no practical limit to the endurance of the Britannia and Conway tubular bridges; although ¾-in. plates of the same material exposed to the wash of the sea had completely wasted away in two years. The bridges are, however, so well looked after that it was estimated that they would not be corroded through in less than 1,200 years.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the above Institution—the last of the session—was held at Storey's Gate, Westminster, on Friday last, the 28th ult., the President, Dr. H. S. Hele-Shaw, F.R.S., occupying the chair.

Action of Cutting Tools.

The paper set down for reading and discussion was one entitled "An Account of Some Experiments on the Action of Cutting Tools," by Professor E. G. Coker, M.A., D.Sc., F.R.S., Member, and K. C. Chakko, D.Sc., of University College, London. Prior to the reading, Professor Coker pointed out that the paper was presented originally as a report to the Cuttings Tools Research Committee of the Institution, but it had been suggested to him that he should read it as a paper for discussion at a general meeting. We reprint this paper on page 564 of the present issue.

The President, in opening the discussion, remarked that the older members of the Institution would, perhaps, scarcely have expected to see such results as they had been shown so beautifully represented by colours. He had asked Professor Coker to explain his method of working, and he thought members would admit that he had admirably succeeded in so doing.

Mr. P. V. Vernon, O.B.E., spoke first, remarking that, as a member of the Cutting Tools Research Committee, he had read the paper with great interest. He regarded the method shown by the author as little less than a revelation to practical engineers. He had, however, some doubt as to what bearing the results would have upon the work of the committee, and upon that of engineers generally, in endeavouring to obtain more knowledge of the action of cutting tools. Perhaps he might define the difference between the scientific man and the engineer, thus: the former was seeking for facts without regard to their usefulness, leaving the latter to utilise those facts when obtained. The engineer, as a practical man, sought to turn the facts into something beneficial to himself and the world. Bearing this difference in mind, the facts discovered by Professor Coker should not be treated as unpractical, but the hope entertained that they might be utilisable in connection with machine tools.

It seemed to him that much the same coloured features would have been obtained if Professor Coker's disc had not been rotated at all, but had simply been allowed to press on the tool, the experiments being made statically. If that were so, it became necessary to search for the relation between the experiments and the actual cutting action of the tool. As an engineer, he was much interested in the construction of the authors' extensometer, measuring, as had been stated, variations in thickness in a moving surface within one millonth part of an inch. It would be of great interest if Professor Coker would say more about this instrument. The facts that above the tool the metal was in compression and below the tool in tension were obvious, but the pictures of the results were new.

The authors had stated in the paper that the work required to remove a given weight of nitro-cellulose was a constant within the limits of the experiments. He took it that what the authors meant was that the work required to remove a given amount of material was independent of speed. In 1908 he had made experiments showing that the amount of work required to remove a given weight of steel was practically independent of the speed, and he would give some of the results obtained. Taking the case of a 2-in. bar reduced to 1¾ in., the cutting speed varying from 107 ft. to 210 ft. per minute, the metal removed in pounds per horse-power per minute varied from 0·33 to 0·37, showing that the amount of metal removed per horse-power per minute was practically constant for that variation of cutting speed. In a screwing test, in which a 2-in. Whitworth bar was screwed at speeds varying from 5·76 ft. per minute up to 10·47 ft. per minute, the ratio of horse-power to revolutions per minute remained practically identical all the way through, signifying that the pressure on the dies was the same, no matter at what speed the work was done.

Colonel R. E. B. Crompton, C.B., referred to the difficulty in adapting the knowledge undoubtedly gained by Professor Coker's work to the actual conditions under which he himself was studying cutting action. His endeavour was to ascertain the nature and extent of the cutting forces when cutting materials of various classes, between soft cast-iron and very hard cast-iron, and through four grades of steel; eventually he hoped to deal with the non-ferrous metals; the process was a long one. The forces he required to check were measured by electrical means. He agreed with Mr. Vernon that the stresses indicated in the material were what would be expected. He also shared Mr. Vernon's difficulty in believing that the thickness of the disc could be measured in millionths of an inch; he had found it difficult to measure the same thing in ten thousandths.

He considered that the authors were right in tackling the case of two-dimensional work—simply paring a thin disc—yet, as that condition of cutting rarely occurred in practice, he had difficulty in seeing how the indications thus secured could be applied to three-dimensional forces, such as always existed when dealing with material in a lathe. In the latter there were directly radial, and also sideway forces due to the traverse of the lathe, producing components not at all easy to calculate, or even form a mental picture of. One of the interesting photographs shown by Professor Coker indicated that when a tool was not perfectly sharp the shaving would come off in a discontinuous manner, alternating dark and light spaces being visible. He could confirm—so far as it was possible from careful observation and photographic enlargements—that nearly the same thing occurred when turning steel; cast-iron he had not considered in this relation. In turning steel, forces of the nature investigated by the authors only endured for a very few moments after the tool was started. Almost immediately after, a second stage of cutting was entered upon, and from that point the cutting was intermittent. Observations of the chip showed that, when enlarged 50 times and photographed, the chip invariably consisted of a very thin inner layer which was continuous, on to which the whole of the rest of the chip was piled in a series of slabs lying on one another in a slanting direction, the whole welded together. That they were welded together was evident from the great tensile strength of the chip. The mere act of cutting and its effect on the tool was of no great importance until this second stage was reached, the stage at which the tool was breaking away the material. An artificially formed edge was invariably set up after the first few feet of cutting, and that edge did not resemble the original ground and stoned edge with which the tool started. The edge had an artificial angle imparted to it by the scouring away of the upper surface of the edge as illustrated by photographs which he had secured.

He thought the effect in question so remarkable that few who had not had the advantage of working

under a high power microscope, as he had recently had, would appreciate it.

Sir A. G. Hadcock, K.B.E., F.R.S., stated that at Elswick experiments had been carried out on very thick cylinders, the results of which had not proved in accordance with theory, partly, no doubt, because the steel had been stressed beyond the elastic limit, purposely so, as certain results were expected. He thought that perhaps Professor Coker's methods might be utilised in the particular investigation alluded to. Professor Coker had kindly referred him to the paper he had read before the Royal Institution in 1916, in which results were given with a cylinder made out of sheet celluloid. A doubt had arisen in his mind as to whether the thin sheet celluloid would behave in an equivalent manner to ordinary forged steel. On that point he was still uncertain, but there was no doubt that the authors' experiment did correspond closely with calculation.

Colonel R. E. B. Crompton, in reply to a question put by Mr. E. R. Dolby, stated that he had made many experiments with and without lubrication. He had found it so easy to calculate the difference in cutting force with lubrication and non-lubrication, that he had decided to carry out his experiments without lubrication, on account of greater accuracy and ease of observation. The employment of lubrication produced very irregular cutting forces. At the speeds at which he had operated—mostly 40 ft. per minute—he could work within the limits of temperature allowable with the cutting steels in use.

Dr. F. W. Lanchester remarked that he wished to ask the author whether he considered the section of a shaft was fairly represented by his disc, or whether he had reason to think his results would be modified by the three-dimensional form. Another question he would ask was whether it would be possible to extend the investigation so as to deal with such stresses as occurred in the corners of a parting tool, and whether he would be able to get stress diagrams representing what was taking place in the face of the parting bar. He suggested that the experiment might be conducted by means of two parting tools face to face cutting into the sides of the disc instead of the periphery.

Mr. J. E. Sears, of the National Physical Laboratory, referring to measurement of the thickness of the disc, observed that the disc itself must either have been measured unstressed at every point at which it was subsequently measured stressed, or else it must have been an extraordinary piece of work to obtain a nitro-cellulose disc 6 in. in diameter uniform to a millionth of an inch in thickness. Unless Professor Coker had some method of pre-determining the thickness and then measuring the differences, the operation would be particularly difficult. He would be much interested to learn how it was possible to measure the disc to a millionth of an inch while it was in motion.

Colonel H. I. Brackenbury, C.B.E., said with heavy cutting, the point of a tool did not actually touch the metal being cut. A piece was welded on, the chip impinging on the tool as far as $\frac{1}{4}$ in. away from the point. When turning very slowly the chip curled up sharply and broke off into small pieces. If the speed were increased the cutting curled off to a bigger radius, while at a speed of 120 ft. per minute the cutting would come away practically straight, and might be dangerous to the workman. He had never seen any clear explanation of that fact. When the cutting came off slowly, it would be comparatively cold, a circumstance which had nothing to do with the speed, but was due to the fact that it parted with its heat into the main body. The faster the cutting came off the hotter it was, as it was unable to transfer the heat to the main body rapidly enough. He assumed that the speeds in the case of the authors' experiments were very slow speeds; with slow cutting, there was time for the heat to be conducted away.

The President having enquired what the size was of the disc used in the experiments, Professor Coker replied that the diameter was 6 in. and thickness $\frac{1}{2}$ in.

Professor Coker, in reply to the discussion, said the paper was only a "preliminary canter." Two other machines were in course of completion for experiments in planing and milling. With regard to Mr. Vernon's remarks, the work had been undertaken at the instigation of the Committee of which Mr. Vernon was a member, and was so undertaken from a purely scientific aspect. The lateral extensometer used to obtain a measure of the sum of the principal stresses at any point, is illustrated in Figs. 1 and 2 reproduced herewith. A was a U-shaped frame carrying a calibrating screw B on one limb, with its point resting against the specimen. The latter was shown under compression stress between the plates D_1, D_2, of a small testing machine. The other limb carried a needle E, the inner end of which touched the specimen, while the outer end bore against the short arm of a bell-crank lever F pivoted at G. The long arm of the bell-crank lever controlled the angular position of a pivoted mirror H, on which a spot of light was

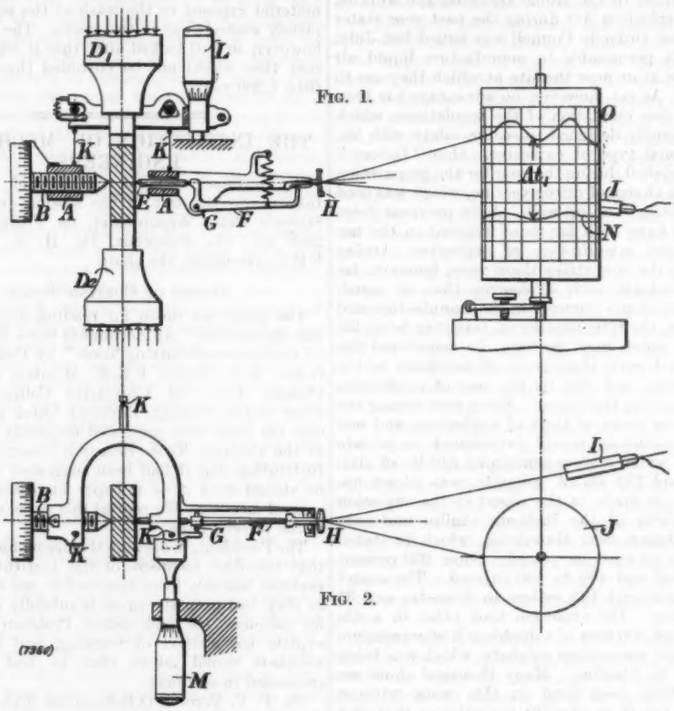


FIG. 1.

FIG. 2.

directed by a lamp I, and the position of the image was recorded on the drum J. The extensometer itself was suspended by a three-wire suspension K, or its equivalent, from a slide controlled vertically by a micrometer screw L and horizontally by a second micrometer screw M, so that the lateral change at any part of the specimen could be measured. The suspension would be seen in Fig. 3 of the paper (page 565).

The experimental difficulty due to possible irregularities in thickness of the specimen was easily overcome in the following manner: The local irregularities of the surface were first measured by traversing the extensometer along a definite line in the plate under measurement, and its changes of thickness were marked on the drum J, which was usually turned by hand to give 1 in. of movement to $\frac{1}{15}$ in. movement of the extensometer. These readings usually gave a wavy datum line N. When a load was applied to the specimen, a corresponding line O was obtained. The change of thickness $A t_1$ due to the load for any given point on the specimen was then given by the vertical distance between the two curves, subject to small corrections due to the angularity of the reflected beam of light. Here

$$A t_1 = \frac{p_1 + q_1}{M E} t_1$$

To calibrate these readings a member under pure tension of compression was cut from the same plate and loaded in a similar fashion. Suppose it gave a change $A t_2$ for a stress p_2, then we had

$$A t_2 = \frac{p_2}{M E} t_2$$

Hence

$$p_1 + q_1 = \frac{t_2}{t_1} \cdot \frac{A t_1}{A t_2} \cdot p_2$$

and the sum of the principal stresses was obtained in terms of a known stress p_2 without introducing any physical constants. Usually t_2 and t_1 were so nearly equal that there was no perceptible error in assuming them to be so. An incidental advantage of this method was that the sheet of squared paper on the drum gave a record of the measurements, and all troublesome workings of readings and subsequent reductions were avoided.

There had so far been little progress in the direction of three-dimensional work. A great deal of information as to what was happening in the case of three dimensions could be obtained from the knowledge gained from experiments with two dimensions.

Sir Alfred Hadcock had inquired whether nitro-cellulose behaved like steel. Within the elastic limit the effects were precisely the same; beyond that limit it was a different matter. He considered that there was no reason why the experiments with this transparent materials should not agree in relation to the same kind of stress distribution obtained with steel. With regard to Dr. Lanchester's suggested experiment with a parting tool, it appeared to be perfectly feasible, and he would take an early opportunity of trying it.

The President, in bringing the proceedings to a close, said the discussion on the authors' experiments had proved valuable. He did not consider that anything said in the course of the discussion in any way diminished the practical value of the work done. He then announced that the Summer Meeting would take place this year in Paris and in Liége. An outline programme and full particulars of the meeting would be issued to members in the May number of the Journal. Two hundred applications for attendance had been received. He hoped the meeting would be a success in spite of other conferences on the Continent of which they heard. He might say, having just returned from Paris, that among Paris engineers a very cordial feeling was manifested towards brother engineers in this country.

THE IRON AND STEEL INSTITUTE.

THE fifty-third annual general meeting of the Iron and Steel Institute commenced yesterday and is being continued to-day, at the Institution of Civil Engineers. Dr. Stead, the retiring President, was unable to attend owing to ill health, and in his absence Dr. Arthur Cooper occupied the chair at the opening meeting.

THE REPORT OF THE COUNCIL.

The report of the Council stated that during the year 1921, under review, 139 new members and 27 associates were elected, and 7 associates were transferred to full membership; 62 members had resigned, and the names of 30 others were removed from the register in consequence of the non-payment of their subscriptions. Further, the death of 32 members had been reported to the Council. The total membership on December 31 last stood at 2,228.

The report then gave the names of several members upon whom various honours and distinctions had been conferred during the year. It also referred to the accounts, and stated that the total receipts for the year under review, apart from the income of the Carnegie Scholarship Fund, amounted to 8,349*l.*, the expenditure having been 6,866*l.* The effect of the increase in the amount received for subscriptions was clearly shown in the accounts, the receipts from this source having been, during 1921, 6,195*l.* in respect of 2,228 members, as compared with 4,404*l.* in 1920, when the membership was 2,193. The journal printing expenses had also decreased, the price of paper having again receded, and the labour charges for printing and machinery having been somewhat reduced, as compared with the high level at which they stood during and immediately after the war.

COMMITTEE WORK AND COUNCIL.

Committee No. 2 (Blast-Furnace Practice) held three meetings, and a conference with representatives of the Coke-Oven Managers' Association on the subject of the technical properties required in coke, for blast-furnace purposes and the variations in such properties as occurred in the different localities in which coke is produced, a joint committee having been appointed to confer further on the subject.

A meeting of Committee No. 3 (Steel and its Mechanical Treatment and Ferro Alloys) had been held, and Mr. Cosmo Johns and Mr. W. J. Brooke had kindly undertaken to compile comparative data in regard to open-hearth furnace design, and to collate the data already in the possession of the Committee.

Committee No. 5 (Metallography, Physics, and Chemistry: Sub-Committee on Standards) held three meetings, and was now able to report that three standard steels had been prepared and placed on the market. They were No. 5 carbon standard acid open-hearth carbon steel (carbon, 0·7 per cent.); No. 6 carbon standard, basic open-hearth carbon steel (carbon, 0·10 per cent.); and No. 1 sulphur standard (sulphur, 0·03 per cent.). No. 2 sulphur standard (sulphur 0·07 per cent.) was in the final stages of preparation, and the following district authorities had kindly undertaken to proceed with the work of selecting material for further standards; Glasgow, acid open-hearth carbon steel (carbon, 0·25 per cent.); Sheffield, acid open-hearth carbon steel (carbon, 1·0 per cent.); Middlesbrough, basic open-hearth carbon steel (carbon, 0·4 per cent.); South Wales, acid open-hearth steel, manganese standard (manganese, 0·8 per cent.). The preparation of a cast-iron standard was likewise in hand.

After referring to the activity of various members as representatives of the Institute in different other Institutions and Societies, the report added that the vacancy in the list of vice-presidents due to the death of Sir Gilbert Claughton, Bart., had been filled by the election of Sir W. Peter Rylands as vice-president. The vacancy caused on the Council by the death of Sir Charles Allen was filled by the election of Mr. A. Hutchinson as a member of Council, while the remaining vacancy in the Council, due to Sir Peter Rylands being elected a vice-president, had been filled by the election of Mr. E. H. Saniter.

Dr. Cooper then inducted into the chair the new President, Mr. Francis Samuelson, who, for many years past, has been member of council and vice-president. The first duty performed by the new president was to present the Bessemer gold medal for the year 1922 to Professor Kotaro Honda, which was received on behalf of the new Medallist by the Secretary to the Japanese Embassy.

Mr. Francis Samuelson then delivered his presidential address. He said that his purpose was to touch upon certain problems of blast-furnace and steel works practice, particularly of the former, and his aim was rather to be suggestive. In regard to steel, he asked to what extent should finished steel be subjected to chemical as well as to mechanical tests; it might be possible at least somewhat to relax the severity of the chemical specifications when the mechanical specifications were perfectly met. For example, there seemed to be considerable variety in the amount of phosphorus and sulphur allowed in rails by various railway companies, the lowest being 0·04 per cent. for either element, and the highest, the British standard specification for bull-headed rails, being 0·075 per cent. for phosphorus and 0·08 per cent. for sulphur. Two railways, over whose lines many of the same trains ran, varied by 0·02 per cent. for both elements—0·05 per cent. in the one case and 0·07 per cent. in the other—with practically the same carbon. If one of these railways were not endangering the lives of its passengers, the other was needlessly increasing the cost of making steel rails and restricting the use of certain ores.

As intimated by Mr. Samuelson, the greater part of his address covered the reducing of the ores in the blast furnace. He dismissed the processes of making steel direct from the ore by stating that a description of all existing commercially practicable "direct" processes of steel-making need perhaps hardly be longer than the Danish naturalist's chapter upon "Snakes in Iceland." He then reviewed the advisability of complete or partial scrapping and rebuilding of a blast furnace plant, and stated that in this country the small profit on pig-iron making militated against the scrapping policy. The actual capacity of all the blast furnaces in the United Kingdom now amounted to about 12,000,000 tons, and seeing that we had never produced more than a little over 10,250,000 tons, we had, apart from possible improvement of plant or methods, an existing reserve of about 20 per cent. over the maximum production hitherto attained. Out of the 278 furnaces actually workable at one time in England and Wales, of which it had been possible to ascertain the output, 115 produced under 750 tons per week and 163 produced over that amount. In this country, added Mr. Samuelson, we had attempted to get, and had succeeded in getting, larger outputs from our furnaces than they were designed for; this had meant over-driving or, perhaps, driving up to the maximum capacity of the plant, leaving no margin of reserve power for emergencies.

He said he believed our usual system was to endeavour to maintain a fairly constant pressure of blast, leaving it to the furnace to say how much air it would take, and that we did not commonly adopt the system by which the aim was to keep up a constant volume of air going through the furnace per unit of time. Which was the better system of the two was a question to be solved. The constant volume system certainly required elasticity in the blowing apparatus; that was to say, that it must work normally at less than full capacity, having a reserve of power with which to deal with difficulties, and whichever system were best, there could be little doubt that a considerable reserve of power was desirable. Here Mr. Samuelson emphasised the difficulties which surrounded the improvement of existing blast-furnace plants. In reviewing the various blowing engines, he stated that the steam turbine saved in first cost, in space, in housing, in oil and in running cost. It was less positive in its action than the reciprocating engine, and could not be over-driven; if it were, it merely churned and heated the air. It was not the best sort of blower to deal with a sticking furnace. In order to be able to meet ordinary variations in the working of the furnace, it had to be normally run at something less than its best economical speed, otherwise it had no reserve of power.

There was no more vital problem, Mr. Samuelson further said, than that of the future of our ore supplies. He briefly reviewed our home resources. He had counted 58 names of imported ores that had been tried of recent years in the Newport furnaces. The future of our industry would be more secure if a greater proportion of the iron ore resources of the world were under our own control. A time might come, if and when the Kent coalfield is further developed, when a big steel industry would be established on either side of the Channel, based on an interchange of the ores of Normandy and Brittany, and perhaps also of the Eastern field of France, with the coal of Kent.

The first papers on the list were then read and discussed at yesterday's morning and afternoon meetings; others are being taken to-day. We shall report the further proceedings in our next issue.

(To be continued).

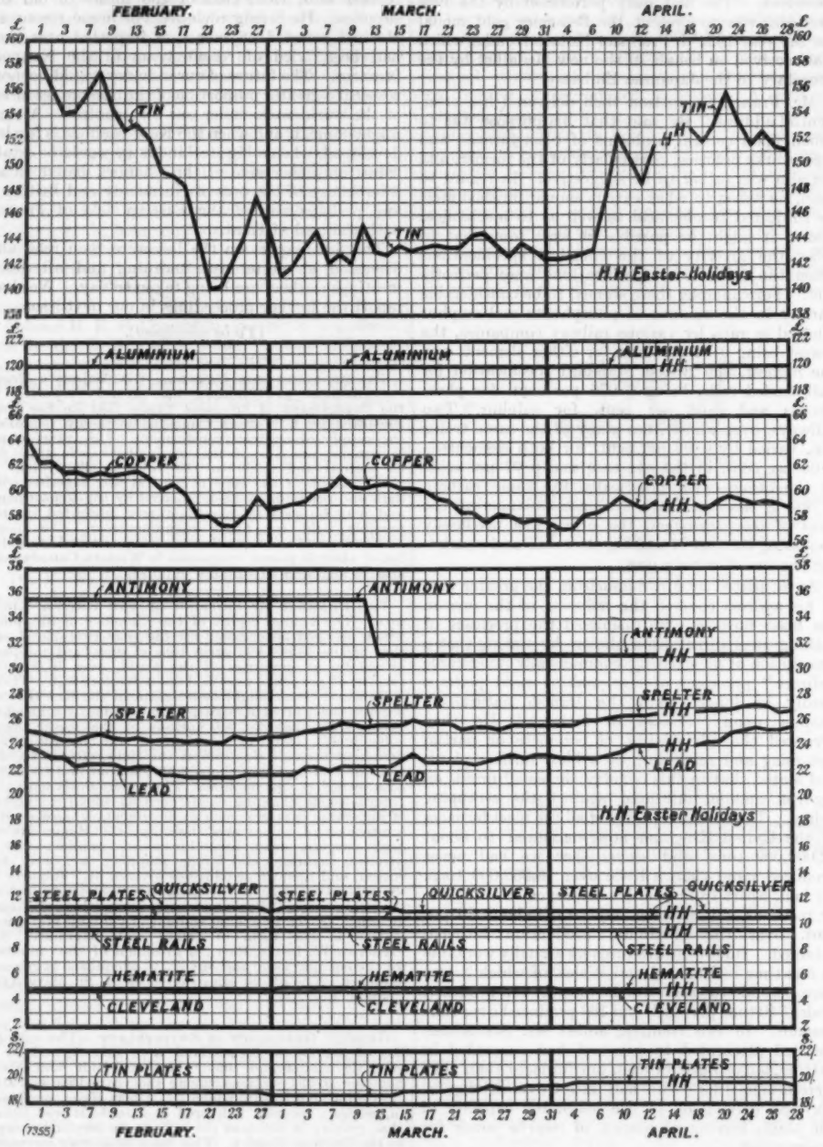
TRANSFORMERS FOR CANADA.—His Majesty's Trade Commissioner at Winnipeg has recently reported to the Department of Overseas Trade that he has been consulted by a Western Canadian company regarding the supply of electric transformers. The transformers in general use are of the single-phase pole type for 60 periods and 2,200 to 110 volts to 220 volts. A rough sketch of the type in general use, together with data and prices, have been received by the Department, and may be seen by manufacturers interested in this possible field for home manufacturers. The name and address of the Canadian company referred to, and a list of electric power companies in Western Canada, will also be supplied to suitable inquirers.

THE CHAMBER OF SHIPPING OF THE UNITED KINGDOM.—The annual report of the Chamber of Shipping, which has just been issued for the year 1921–22, shows that of the 58,800,000 gross tons of merchant shipping owned by all countries of the world, over 10,000,000 tons, or 17 per cent., were laid up in January last. There is, however, some slight consolation in the fact that as regards the United Kingdom, the position is somewhat better than that for all nations of the world taken collectively. Only 12 per cent. of the British-owned merchant tonnage was idle at the time referred to, the tonnage laid up being about 2,250,000 out of 19,300,000 tons owned in this country. The report deals with the International Shipping Conference at which a number of important matters, such as documentary agreements, limitations of shipowners' liability, the Hague Rules, deck cargoes, load line, life-saving appliances and wireless, taxation, and foreign shipping, &c., were discussed, and definite conclusions arrived at. Reports of the annual meeting of the Chamber of Shipping and of the Shipowners' Parliamentary Committee are also included, as well as a large amount of valuable statistical matter in the form of tables and diagrams. Sir Frederick W. Lewis, Bart., is President of the Chamber for the ensuing year, and Mr. H. M. Cleminson is general manager. The offices are situated at 28, St. Mary Axe, London, E.C. 3.

GRAVITY DEFICIENCY IN SWITZERLAND.—The anomalies of gravity in Switzerland were investigated by a geodetic commission under Messerschmidt and Niethammer at 231 stations during the years 1900 to 1918. According to a lecture which Dr. Albert Heim, professor of geodesy, recently delivered at Zürich, it was found that gravity is deficient throughout Switzerland except in the Brissago district. This mass deficiency increases on ascending from the plains of north-west Switzerland (Basle) up to the high Alpine ranges; it decreases subsequently on the southern slope of the Alps, especially in the Canton of Tessin, and is, in accordance with geological considerations, greatest in districts where the folding of the deposits extends to greatest depth. There is generally a deficiency of mass in parts where specifically denser masses have been pushed aside by lighter portions of the earth's crust. Heavy mountains tend to sink until they can be kept floating. There are many observations of peculiar phenomena of erosion, moraines, gravel deposits, &c., which support the view that the peaks of the Alps were once at considerably higher level than they are at present. But the suggestion made by Heim that the peaks once rose to a height of 50 km., instead of the actual maximum of less than 5 km., is startling. The earth is, of course, not stable. There is no constant fixed point of reference; earthquakes are very common, and quiet secular level changes may be proceeding in many unsuspected parts of the earth. The average density of the surface rocks is 2·7, that of the interior of the earth 5·7. Pratt suggested first in 1852 that there was a deficiency of gravity beneath the enormous mass of the Himalaya mountains. On the principle of isostasy, as enunciated by Hayford in 1917, there will be, above each region of deficient density, a bump in the earth ellipsoid, some mountain or plateau, and a depression (ocean) above each region of excessive density; the continents float because they are of relatively light material. It is difficult to say under these conditions to what datum we should refer our level measurements: the sea level appears, in spite of many objections, still best considering that nearly seven-tenths of the earth are covered by water.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

PREVENTION OF IRON CORROSION BY DEAERATION.—Since the rate of the rusting of iron largely depends upon the oxygen contents of the water deaeration of the water can frequently reduce the corrosion of pipes, &c., to a large extent. The paper by Frank N. Speller, on "Control of Corrosion by Deactivation of Water" (Journal of the Franklin Institute, April, pages 515 to 542), is written from this point of view. At 0 deg. C. and normal pressure a litre of water will dissolve 10 cub. cm. of oxygen, and this content will steadily sink to zero as the temperature rises to the boiling point; the oxygen saturation for sea water is slightly lower, but sea water is otherwise injurious. In water pipes and boilers the corrosion shows mainly near the inlet and near the entrance of the feed water. To reduce the oxygen content the water is passed through expanded steel lathing contained in deactivating tanks; steel turnings would clog together in rusting and obstruct the free flow. Kestner (Paris) reverses the flow in such apparatus at intervals in order to reduce the ferric hydrate formed by contact with fresh iron and to produce the more active ferrous hydrate; according to Speller, who describes several installations of the Anti-Corrosion Engineering Company, New York, and refers to various reports on the performances of such devices, little is gained by this reversal, and the tanks will work well for two or three years, when they have to be recharged. He also draws attention to the mechanical deaeration of W. S. Ellcott, who sends the raw water first through the cooling circuit of a main condenser, then into a heater, and discharges it suddenly from the heater into the vacuum of a separator, where an almost explosive boiling takes place; a small portion of the water is diverted through an auxiliary condenser in which steam used in the air ejector (joined to the main condenser) is condensed. This system is said to be very effective when an almost perfect deaeration is desirable. Several other processes are mentioned.

INDUSTRIAL RESEARCH.

THE several researches undertaken by the British Electrical and Allied Industries Research Association are now reaching the stage at which a number of reports and technical publications can be announced, and several more will shortly be available.

The publications on insulating materials include one giving instructions for the study of untreated papers for purposes other than cable manufacture. A full account of the researches on which these instructions are based is also to be published. In addition there are similar reports upon the mechanical and physical testing of pressboards, presspahn, &c., and on vulcanised fibres. The electrical testing of fibrous insulating materials is covered comprehensively by another publication; the scope of the research on electrical tests of all these materials is being extended to include standardised methods suitable for all insulating materials. Sheets, rods and tubes of composite insulating materials are dealt with in another publication. The researches upon which this is based have already proved of great value to the co-operating manufacturers, and marked improvements in their products are reported; a full account of these researches will shortly be issued. Work on the composite class of insulators (still under consideration) includes the evolution of test methods for fire and heat-resisting properties, the practical application of these methods to materials on the market, and work on moulding properties and on the action of solvents and hot oil. The committee on synthetic resins has prepared a technical publication giving directions for the study of synthetic resin, varnish paper and varnish-fabric boards, and also reports on the possibility of establishing and safeguarding in this country the manufacture of raw materials for these resins. Other work in this section includes a report on the requirements of Government Departments with reference to synthetic resin products, and tests upon moulded products. Samples of varnish paper and varnish-fabric boards, and of moulded products are being collected. The uses of mica for condensers and commutators is the subject of a report issued by the committee on mica and micanite. The report deals with the classification, identification and properties of mica; investigations are still proceeding on the mechanical and electrical tests of various kinds of mica. Steps have been taken to clear up the existing confusion in the classification, manufacture and use of micanite, by bringing in close touch all parties interested in this material.

The researches on the electrical strength and resistivity, and on the thermal properties of insulating oils are progressing. The former are to be carried out in close co-operation with Professor J. A. Fleming at London University, where a programme of research has been mapped out. In addition to these specialised researches on insulating materials, the general researches on dielectrics are being actively pursued. New work in this direction includes an investigation of the cathode ray tube as an instrument for the measurement of dielectric losses at high frequencies, and an examination of these losses at high voltages by the use of an electrostatic wattmeter. Three reports are in preparation in the section dealing with conductors. The first will clear up outstanding points on heating of buried cables, except dielectric loss problems; the second report will suggest material improvements arising out of tests on standard wood poles for overhead lines. The third report in this section will treat with test results obtained on long overhead copper cables; the work on aluminium and steel cables is nearing completion.

Several valuable researches, on a practical scale, are progressing in connection with electric control apparatus. These include tests on oil circuit breakers (for which the 6,000-kw. alternator has now been prepared and its characteristic determined), on mining switch gear, fusible cut-outs and air circuit breakers for direct current. This last research has the practical co-operation of the London County Council and the London and North-Western Railway Company, Limited. A forthcoming paper by the National Physical Laboratory is also announced, giving the results of tests on the conductivity of joints in copper and aluminium bars.

Recent researches on stainless steel have necessitated a revision of the programme previously mapped out for research on turbine blading. Good progress is reported in the tests on turbine nozzles at Manchester University. It is interesting to learn that Professor Callendar is undertaking researches on turbines and on the properties of high-pressure and high-temperature steam. Amongst the miscellaneous researches and new inquiries undertaken by the association may be noted: Tests on the relation of the permissible variations of supply voltage to "flicker" of incandescent lamps, conferences with Government departments on accumulators and batteries, and researches on the wave-form of generators. A full review of the progress of all the activities of the association may be found in the Quarterly Progress Report for April.

THE ACTION OF CUTTING TOOLS.

*An Account of some Experiments on the Action of Cutting Tools.**

By Professor E. G. COKER, M.A., D.Sc., F.R.S., Member, and K. C. Chakko, of University College, London.

Introduction.—The mode of action of cutting tools has been the subject of much investigation on account of its great importance to mechanical engineers, who carry out a very large proportion of their work by aid of machinery designed to provide the most efficient action

* Paper read before the Institution of Mechanical Engineers, Friday, April 28, 1922.

of various tools for shaping metals and other materials, but so far it has apparently not been studied by photo-elastic methods. As a preliminary to the description of some experiments which have been made by aid of polarised light at the suggestion of the Cutting Tools Research Committee, it may be of interest to recall, very briefly, the principles upon which such experiments are based.

Nearly all transparent bodies when loaded become doubly refractive, and a ray of ordinary light passing through the material in a state of stress is subjected to a selective retardation whereby its transverse vibrations lag one behind the other. No effect is visible to the eye, since ordinary light consists of such a complex system of transverse vibrations that the eye is unable to detect what is going on, but if ordinary light is, as it were, strained through some kind of sieve whereby a homogeneous character of a particular kind is imparted to it, the effect of stress in the material becomes apparent. The most convenient apparatus for obtaining the homogeneous light mentioned above is a crystal of transparent calcium carbonate, cut in a special way, invented by an Edinburgh optician, William Nicol. Ordinary light, after passing through such a crystal is found to execute its transverse vibrations in one special plane, and this unilateral kind of light is usually called polarised light, and although this is not a very happily chosen designation, yet it seems to be so firmly established that it is hardly possible now to replace this term by a more appropriate one.

If a stressed body is placed between a pair of Nicol's prisms and a beam of light is passed through the combination, colour effects are observed, which are due to the fact that the plane polarised light from the first prism is broken up by the stressed material into two sets of plane vibrations of light, which travel at different velocities through the material. Not only do these two systems of waves travel at different velocities, but they vibrate in planes at right angles to one another. The function of the second prism is to select components in some definite plane from these two systems, so that these latter will interfere with one another. Interference between two sets of light waves in the same plane is visible to the eye, when the light passing through the object under stress is projected on to a screen, and if white light is used brilliant colours of rainbow pattern appear and indicate in a particular manner, to be described later, the stress in the material which the light has passed through. It is owing to this effect that an optical analysis of stress distribution in a transparent body is possible.

Principal Stresses.—Turning to the condition of the stressed body itself, it will be convenient to consider this as a plate loaded by forces acting in its plane, since in all the work considered here only this kind of loading will be met with. If the most complicated kind of loading is imposed on a plate of any form whatever, subject to this condition, some kind of stress distribution is obtained, which, however complicated it may be, has certain characteristic properties of a very simple kind. The most important of these may perhaps be illustrated most easily by reference to an example drawn from the case of a disc, the edge of which is being turned up in a lathe, as shown in Fig. 1. Select any point A in that disc which has a definite and invariable position with regard to the point D of the lathe tool, and imagine a small square placed centrally over the point A as shown. If this square is set in one particular position, it is capable of proof, as text-books show, that the stresses at that point in the disc are perpendicular to the edges of the square and are not so for any other angular position. Further, the intensities of these stresses p and q are such that one is the maximum stress at the point A and the other is the minimum stress at the same point. If by any means it is possible to measure the intensities of p and q and their directions, then it is quite an easy matter to find the stress at the given point in any other direction. The principal advantage of the experiments described here is that both p and q can be measured, and their directions can also be determined at any points A, B and C, provided the law of the optical effect continues to hold. The trial square can in fact be moved from point to point as indicated on the figure, and for each position, the direction determined in which it must be oriented to give stresses normal to its edges. These stresses are distinguished from any others by referring to them as principal stresses, since all others can be derived from them by simple means. It will be convenient here to describe how the directions of principal stress are obtained experimentally by reference to a disc or plate subjected to the action of a cutting tool. For this and all other optical experiments described here, the polarising and analysing Nicol's prisms are set with their own principal planes crossed at right angles.

Now it is an ascertained fact that the two sets of waves, into which the stressed body divides the light ray, are also perpendicular to each other and the directions of their vibrations are those of principal stress. Light, therefore, is stopped everywhere in the plate where the directions of the prisms correspond to similar directions of principal stress, and a series of black bands can be obtained by simply turning the prisms round until the whole field of view has been covered, each direction being marked from the index plates attached to the prisms.

It will be noticed, when this is being done, that although the black bands move, the colours remain stationary, so that the indications of stress intensity are not dependent on the angular rotation. A set of lines marking the centres of these black bands is shown in Fig. 2B and the inclination of the stress in both work and glass tool are marked thereon.

This information with regard to directions of stress is complete, since every part of both tool and work is swept over by the black bands during the rotation of the prisms. For convenience, however, it is generally preferable to show this information in a different manner by lines which run along the direction of principal stress. Some of these are shown in Fig. 2C and are derived from the black bands by a simple geometrical process.

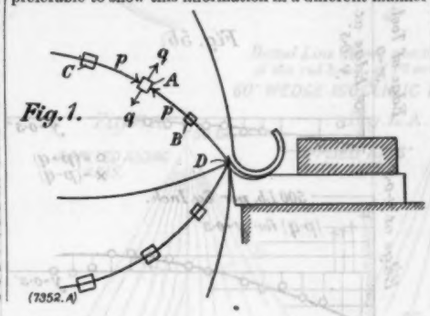


Fig. 1.

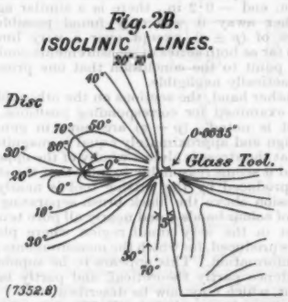


Fig. 2B. ISOCLINIC LINES.

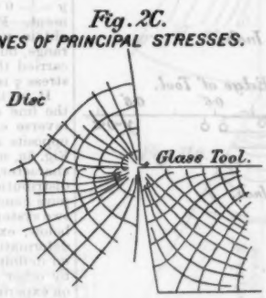


Fig. 2C. LINES OF PRINCIPAL STRESSES.

The effects of stress in both disc and glass tool are shown in the colour photograph, Fig. 2A,* of a light cut being taken from the disc.

Stress Intensity.—The intensities of the principal stresses at each point must now be considered, and the salient fact, which has to be borne in mind in regard to them, is that the colour effect obtained depends on the value of the difference of their intensities at a point. If, for example, p (at A), Fig. 1, has an intensity of 1,500 lb. per square inch in compression, and q has an intensity of 500 lb. per square inch, also in compression, the resulting colour indicates 1,000 lb. per square inch as measured by a comparison member subjected to simple tension or compression stress. If, however, the latter stress q is 500 lb. per square inch in tension, the colour effect is found to be proportional to 2,000 lb. per square inch, and in any case which can possibly arise it is true to say that colour effect is proportional to $p - q$. A band of colour of the same tint throughout, therefore, indicates that along it $p - q$ has a constant value, and this latter value is measured most conveniently by comparing it with a tension member subjected to such a pull that both colours are exactly matched, for then the stress in the tension member measures $(p - q)$ exactly. For some purposes this may give all the information required, but in general it does not do so, and a way has to be found to separate p from q at every point.

Before describing a method of carrying this out, it is of interest to observe that the law of colour effect is such that a black band or an area may occur which has nothing to do with the direction of stress, since if $(p - q)$ happens to be zero at any place, the field of view will be dark there, but when such places occur they are easily distinguishable, since they remain fixed when the prisms are rotated, while the directional black bands do not. Hence there is no difficulty in practice in assigning a meaning to a stationary black part of the field; it is, in fact, to be regarded as a part of the fixed colour scheme which the forces acting on the body have imposed upon it.

In order to understand the method used here for separating the stress q from p, it is necessary again to consider a simple square of the material under stress, such as occurs at any point, say A, Fig. 1. Under the action of one principal stress the square changes in thickness by a definite amount, and if it were the only stress the change of thickness would be exactly the same as occurs on a simple tension member cut from the same plate and under the same stress. In general the little square is also subjected to stresses q in a direction perpendicular to the stresses p, and if both are alike, the change of thickness will be larger than before and be proportional to $(p + q)$. If they are unlike, the change of thickness will be smaller, but in any event its magnitude remains proportional to $(p + q)$, and can be expressed in terms of the stress in a simple tension member.

These changes of thickness are required, in general, wherever colour stress values are measured, and it is clear that if the sum and the difference of p and q are obtained, it is merely a simple addition or substraction sum to separate them.

The actual measurements are performed by a very delicate extensometer, which is moved over the body to measure these changes wherever required, and in the present experiments the observations show that although the body under observation is continually moving there is no serious difficulty from this cause.

Experimental Apparatus.—Having now described the general principles on which this photo-elastic investigation is based, some attention may now be devoted to the problem in hand, namely, the study of the action of cutting tools by this method. It was a matter of some difficulty to decide upon the most appropriate course to take as a commencement, since there are so many forms of cutting tools and a great variety of ways in which they are applied in machines for planing, drilling, turning, milling and the like. As a general rule, it is nearly always best to take the simplest example of an experimental problem and work up to the more complex cases by stages. From this point of view the action of a planing or shaping tool seemed to offer the most appropriate form of experiment to start with, since such a cutting process is probably simple as compared with the others mentioned above and the edge is a straight line. It is, however, open to the objection that the cutting action cannot be carried on continuously, and is therefore not so suitable for observation as others in which there is no break in the cutting process. Turning operations offer much more chance of obtaining long-continued observations, and it was therefore decided to construct a simple form of lathe, which would enable the action of both work and tool to be observed in the polariscope.

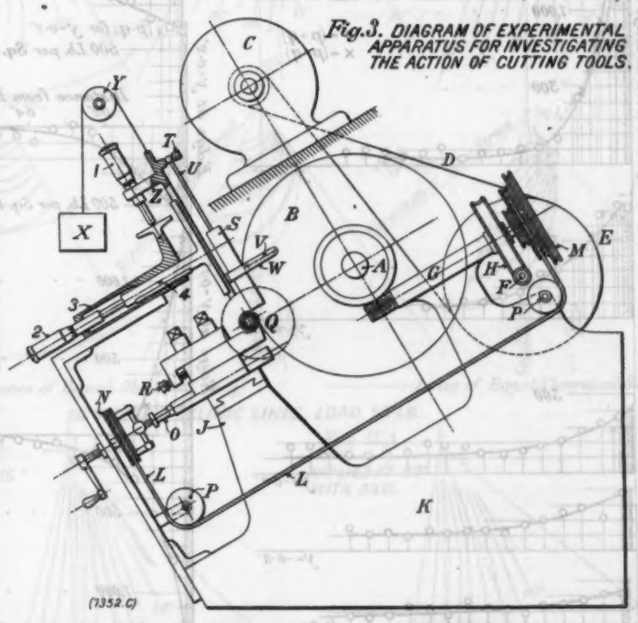


Fig. 3. DIAGRAM OF EXPERIMENTAL APPARATUS FOR INVESTIGATING THE ACTION OF CUTTING TOOLS.

An experimental apparatus was therefore constructed, and after some alterations, which experience in early trials suggested, it took a form substantially as shown in the diagrammatic representation, Fig. 3, in which a spindle A, carrying a transparent disc B, is driven from a motor C, by a band D wrapped round a pulley E on a first-motion shaft F, which latter drives a second-motion shaft G by a worm-wheel gear H. The second-motion shaft G drives the spindle A by a further worm-wheel drive, as shown, thus ensuring a very steady and slow drive for convenience of the photo-elastic measurements. In order to obtain a considerable range of speed variation, the pulleys have several steps, also

* The figures referred to as 2A, 4A, 4B, and 15C, in this paper, being colour photographs, cannot, unfortunately, be reproduced in our columns.—ED E

the speed of the motor can be varied. A small slide rest J, of the usual pattern, is mounted on the frame K of the machine, and the lower slide is actuated from the second-motion shaft by an endless leather belt L, which latter passes over a coned pulley M on the second-motion shaft, and over a pulley N secured to the feed screw O of the lower slide. Guide pulleys P are provided to permit this motion, and to give enough tension in the belt to ensure a uniform radial feed; in practice this was satisfactorily obtained. The tool Q is secured in the ordinary way, and a steadying screw R, pressing against the end of the tool, prevents radial slip. The whole arrangement is devised to permit the passage of a beam of light through the disc and through the glass tool when the cutting action is in progress. The stress distribution in both can then be studied by aid of the coloured bands which appear in both the work and the tool.

The colour photograph, Fig. 4A, showed the general features of interest observed in a disc under the action of a steel cutting tool, the edge of which has been carefully set on a stone, and it would be noted that above the tool there were coloured bands which appeared to spring from a point close to the cutting edge, and to curve round towards the boundary above the tool in approximately circular arcs. Below there was a second set of coloured bands much more limited in extent, springing from near the point of the tool, and forming approximate circular arcs which met the boundary below. These two systems are separated by a black band or brush which varies somewhat in position with the speed of cutting, and with the principal angles of the cutting tool. It is also worthy of note that very near to the point of the tool an intensely black spot is found, which varies slightly in position according to the running conditions. It forms, in fact, a good qualitative index of the steadiness of the running and of the uniformity of the cutting action. It is of particular interest to note that there is a black patch in the shaving immediately above the tool, which remains stationary in time, but not in position, as, although the shaving is intensely coloured after leaving the tool, the black patch disappears in this case. It does not vanish with a badly ground tool, as will be shown immediately, and some very interesting phenomena are observed which will require much further study for their complete elucidation.

Before proceeding to an analysis of these phenomena, it will be convenient to describe the arrangement of the extensometer for lateral measurements shown in the diagram, Fig. 3. The extensometer available was not constructed to work in a vertical position, although it can be made to do so, and it was, therefore, necessary to tilt the experimental lathe, as shown, so that the frame S of the extensometer could be suspended from a three-point suspension, formed by a spherical ball joint T on the tail rod U, and two wires V carried by extensions W from the slide rest J. The extensometer and slide rest are partially balanced by a weight X, which hangs from a stout thread passing over a pulley W and attached to the slide Z, and the motion of this latter is controlled by a micrometer screw 1 reading to thousandths of an inch. A second micrometer screw 2 at right angles, in a casing 3 supporting a cross-slide 4, serves to adjust the radial position of the extensometer. The arrangement, in fact, permits of the extensometer being brought to any position, with reference to a pair of rectangular co-ordinates perpendicular and tangential to the disc periphery, for measurement. It can also be used for determining the lateral change in the tool, although this has not been done up to the time this report was presented, and, as will appear later, it seems possible that this latter measurement may not be necessary.

Fig. 5a.

COMPLETE STRESS DETERMINATION IN DISC WITH 45° CUTTING ANGLE AND 0·015 INCH THICKNESS OF CUT.

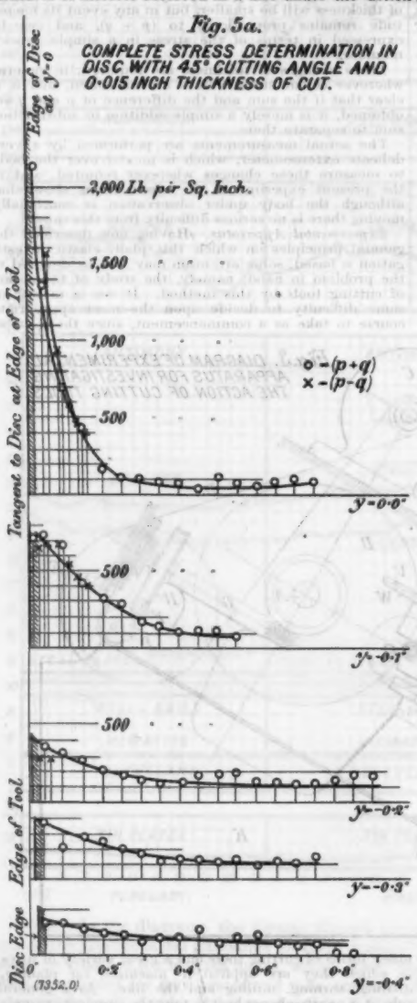
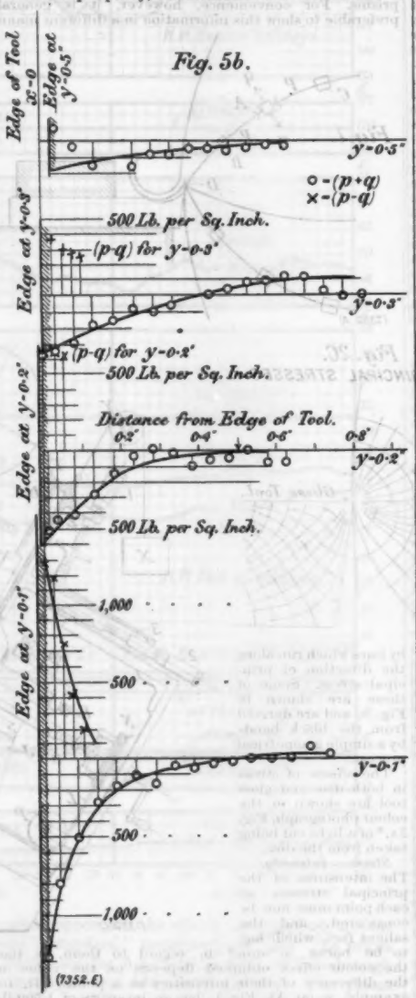


Fig. 5b.



The Stress Distribution in a Disc caused by the Action of a Turning Tool.—The general appearance, in polarised light, of a disc under the action of a cutting tool, has already been described very briefly for a tool with a very sharp edge, but if the conditions are varied there are some notable differences which may be suitably described here. A tool with an edge finished by grinding in the usual way, and an angle of from 45 deg. to 60 deg., produces an action quite different from one with a similar edge, but finished on a stone as perfectly as possible. In the former case the cutting action is very imperfect, and the material is broken away from the disc by a wedge action in which, apparently, the shaving is bent away from the disc by the upper face of the tool; and is torn off with little or no true cutting action. This is accompanied by notable changes in the colour effects, which follow a cycle pulsating about a mean position. The shaving also presents a series of light and dark patches corresponding to these cyclic changes, as shown in the colour photograph, Fig. 4B. The edge of the disc is left in a ragged condition and somewhat wavy in outline, so much so, in fact, that in some cases the main shaving broken off in this way is accompanied by a very thin shaving quite separate from the main one, and pared off by a true cutting process. A similar effect, in metals, has been noted by other members of this committee. That it is possible to obtain a somewhat similar effect, in the turning of cast-iron, is well known, only in this case the cast-iron chippings are accompanied by a fine powder of cast-iron falling from the cutting edge of the tool.

Another interesting matter to which attention may be drawn is the effect of change of speed when a sufficiently sharp and properly-formed cutting tool is used, so that colour pulsations are avoided. With a uniform cut of, say, 0·02 in. on a 6-in. disc the colour effects appear to be quite constant over a considerable range of speed, but as even the maximum speed of this experimental apparatus is very low, say, one turn in 30 seconds, it is not possible to infer that this unchanging appearance of the colour bands would always be maintained. So far as the experiments have been carried, it appears to be true that the stress distribution remains invariable over a limited range of speed, therefore the total work done is a linear function of the speed. It may therefore be said that the work required to remove a given weight of nitro-cellulose is a constant within the limits of these experiments for a cut of definite thickness.

The measurements of the stresses in the neighbourhood of the tool were not found to present any great difficulty, and although some had been expected when measuring the sum of the principal stresses with a moving disc, yet they proved to be rather easier to measure than the difference values from the colour phenomena, especially at low stresses. These measurements are conveniently described with reference to the stress distribution found in a 6-in. disc subjected to the action of a tool with a cutting angle of 45 deg. when removing a shaving of 0·015 in. thickness. These observations are plotted in Fig. 5A for a number of sections parallel to a radial line passing through the centre of the cutting edge of the tool.

On referring to the first series of these observations, where $y = 0 \cdot 0$, that is, along the radial line, it will be noticed that the $(p \pm q)$ values are nearly alike throughout the range of possible observation, and that, for $y = -0 \cdot 1$ in. and $-0 \cdot 2$ in., there is a similar agreement. Farther away it was only found possible to obtain values of $(p \pm q)$, except over a very limited range, but so far as both series of measurements could be carried they point to the conclusion that one principal stress q is practically negligible.

If, on the other hand, the sections on the other side of the line are examined for corresponding positions, the reverse effect is noted. $(p - q)$ are now, in general, opposite in sign and approximately equal in magnitude, Fig. 5B, so that the stress is almost wholly of the opposite character, and it seems reasonable to infer that the stress distribution produced by the cutting tool is nearly all pure compression above the black brush separating the two systems of colour bands; and nearly all pure tension below, except in the very small region where plastic deformation is produced, for which the measurements give no definite information. This appears to be supported by other evidence partly theoretical, and partly based on experiment, which may now be described.

The application of a simple force P, Fig. 6, applied at a straight boundary of a semi-definite plate has been examined experimentally* for the case in which the force is exerted perpendicularly to the boundary, and it is shown that for any part of the plate, except at and near the point of application where the stresses in general exceed the yield-point of the material, there are only purely radial stresses which conform to the formulæ of the theory of elasticity as obtained by Boussinesq, namely,

$$\widehat{rr} = -\frac{2P}{\pi} \cdot \frac{\cos\theta}{r}, \quad \widehat{r\theta} = \widehat{\theta\theta} = 0,$$

where P is the applied force per unit thickness of plate and r, θ, are the co-ordinates of the stress $\widehat{rr}$, with reference to the point of application O of the force and its direction. For this case, therefore, the curve for which the stress difference is constant corresponds to $\widehat{rr} = \text{constant} = C_0$, say, therefore,

$$r = -\frac{2P}{C_0 \pi} \cdot \cos\theta,$$

so that the colour bands are circles tangential to the boundary at the point O. This result, as Menager points out,† may be used to obtain the effect of an inclined force at a straight boundary, a case that has some resemblance to that of the action of a cutting tool.

If, instead of a force P pressed against the plate, a tension P is applied, then both the stress and the strain system will be reversed, therefore two semi-infinite plates stressed in each of these ways, when brought edge to edge, so that the directions of the applied forces are in the same line, will fit one another at the boundaries, and the latter may therefore be considered as annulled. If a small pin P, Fig. 7, passing through a plate and firmly cemented thereto, is pushed in any direction, it will give an effect corresponding to the combination of applied forces described above, and in such a case the colour effects observed will be circles in front of the pin with centres in the line of direction of the force, and all tangential to a line through the pin and at right angles to this direction. In addition there will also be circular bands denoting radial tension stress behind the pin

* "Contact Pressures and Stresses," by Professor E. G. Coker, K. C. Chakko and M. S. Ahmed. Proc. I.Mech.E., March, 1921.

† Contribution à l'étude de la Deformation Elastique des Solides, A. Mesnager. Annales des Ponts et Chaussées, 1901.

of exactly the same type as the former set, as shown in the diagram.

However, it is not necessary that the original plane of separation should be R.S. perpendicular to the direction of the force applied to the pin at P. It may be taken in any other direction through the pin without invalidating the argument. For example, a new plane A B may be taken, and we then have a stress system on the left of this plane produced by a force at P inclined to this boundary and exerting a push upon it, while the stress system on the right hand side may be considered to be due to a pull on the pin and inclined to the boundary. If now only the former system is considered, a system is obtained, as shown in Fig. 7, in which constant stress difference is marked by arcs of circles, all of which terminate at the point of application of the force, and have their centres in its line of direction. One set denotes radial compression, and the other radial tension. If this system is compared with the photograph, Fig. 4A, of the disc under the action of a cutting tool, the general resemblance to this form of distribution is apparent; but it is presumably not exact, since in the neighbourhood of the cutting edge the material turned from the disc passes into the plastic state as it comes under the action of the tool, and the stress system there is possibly of a much more complex kind.

It is apparently, unnecessary to resort to the assumption of the fitting process described above, as it is shown* that if a force P is applied to the straight or curved boundary of a semi-infinite plate the stress system is given by

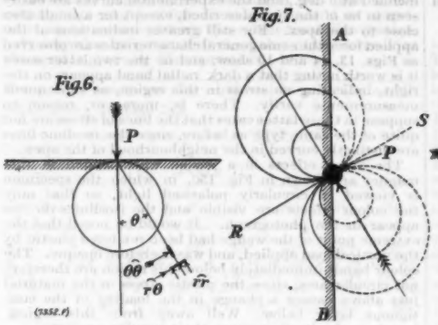
$$\widehat{rr} = -\frac{2P}{\pi}\cdot\frac{\cos\theta}{r}, \quad \widehat{r\theta} = \theta\theta = 0$$

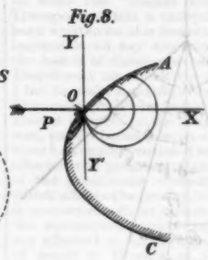
where the direction of the force is taken as the initial line, and the stresses are averages taken through the thickness of the plate.

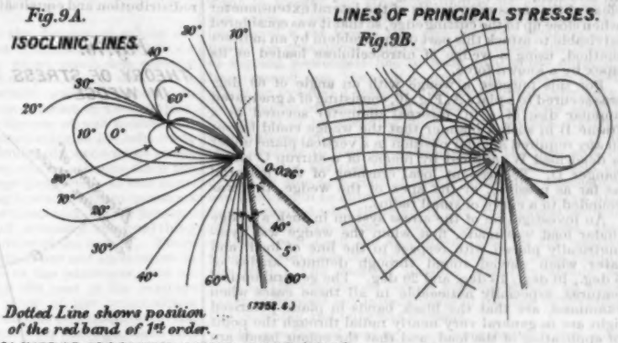
We have, therefore, for a curved boundary A O C, Fig. 8, to which a force P is applied at the point O, a radial stress system at this point, indicated in the polariscope by circular bands of colour with centres in the line O X and all passing through the point O. All parts of the body to the right of the line Y O Y' will be in compression, and all parts to the left will be in tension. One set of the lines of principal stress will radiate from the point of application of the force and the other will be arcs of circles with this point as centre. Apparently, however, there will be unbalanced forces at the contour which will require equilibrating.

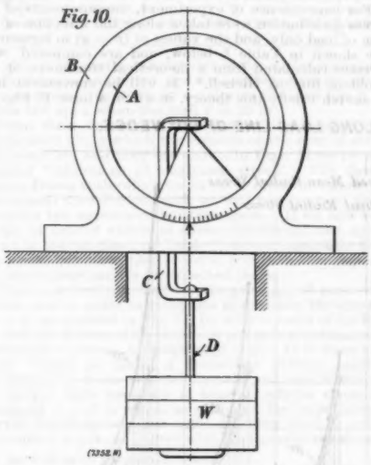
If this system of stress lines be compared with those actually obtained here, it is at once seen that there is not a complete agreement, Figs. 9A and 9B, for in the disc the lines of principal stress are more complicated in character, and it is probable that the curves of equal $(p - q)$ are not exactly circular arcs.

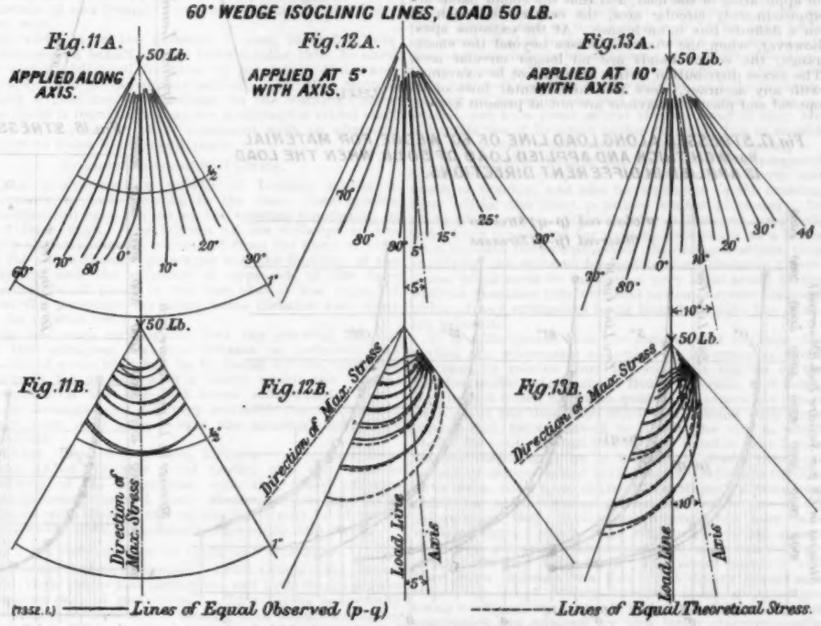
The Stress Distribution in the Cutting Tool.—Early experiments made with a glass-cutting tool, Fig. 2C, page 565, seemed to show that the stress system in the tool is possibly of a simple type, such as might be produced approximately by the action of a single force acting at the cutting edge. There is some difficulty in ascertaining completely the distribution of stress at the extreme point of a glass cutting tool in action for several reasons. The optical constant of glass is small and the colour bands are not therefore so readily observable as in nitro-cellulose, while its elastic coefficient E is high. In plate glass, for instance, the value of E as measured* is 10,500,000 lb. per square inch, as compared with, say, 300,000 for nitro-cellulose, while the Poissons' ratios $m = \frac{1}{\sigma}$ =

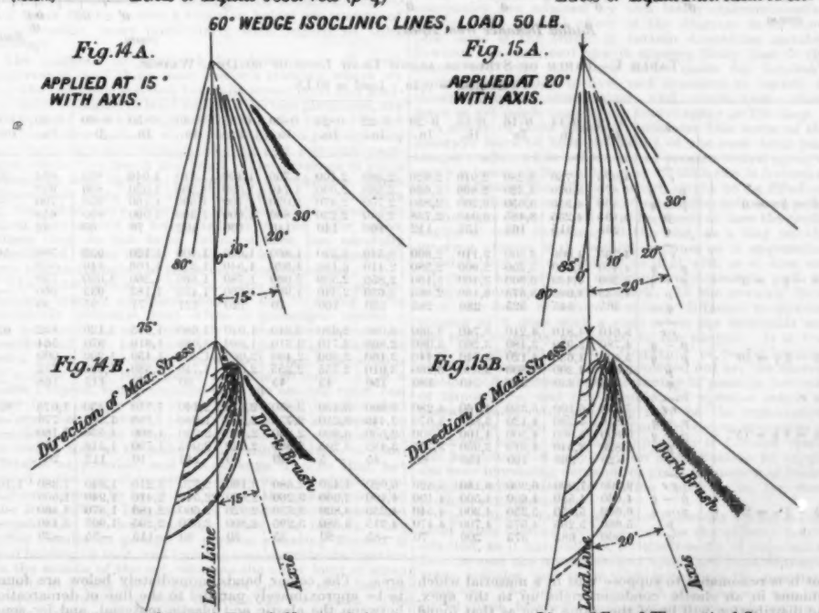












* Proceedings London Math. Soc., vol. xxxii, 1900, and "The Mathematical Theory of Elasticity," by A. E. H. Love, F.R.S., pages 207–228, Second Edition.

* "An Investigation into the Elastic Constants of Rocks, more especially with Reference to Cubic Compressibility," by F. D. Adams and E. G. Coker. Proceedings, Carnegie Institution of Washington, 1906.

are 4·4 and 2·5 respectively. The ratio of m E in the two cases is therefore about 1 to 62, and the lateral changes in glass and nitro-cellulose are also in this ratio. In addition, there is difficulty in keeping the shaving clear of the measuring points of the lateral extensometer when close up to the cutting edge, so that it was considered advisable to attack this part of the problem by an indirect method, using a wedge of nitro-cellulose loaded at its apex by a known force.

For this purpose a wedge with an angle of 60 deg. was secured to a plate A, Fig. 10, consisting of a graduated annular disc of 4 in. internal diameter secured in a frame B in such a manner that the wedge could be set in any required angular position in a vertical plane under a dead load W, applied by means of a stirrup C and a hanger D. To prevent local crushing of the material as far as possible, at the apex of the wedge, this was rounded to a curve of small radius.

An investigation of the stress system in such a wedge under load was made, first when the wedge was symmetrically placed with respect to the line of load, and later when moved round through definite angles of 5 deg., 10 deg., 15 deg. and 20 deg. The general optical features, especially noticeable in all these cases when examined, are that the black bands in plane polarised light are in general very nearly radial through the point of application of the load, and that the colour bands are approximately circular arcs, the centres of which lie on a definite line in each case. At the extreme apex, however, when the material passes beyond the elastic range, the colour bands are no longer circular arcs. The stress distribution in this area cannot be examined with any accuracy, since the fundamental laws of its optical and plastic behaviour are not at present known, but it is reasonable to suppose that in a material which remains in an elastic condition right up to the apex, the distribution will be of the same type as that found in the elastic region of a nitro-cellulose model.

Under a symmetrically disposed load the isoclinic lines are found to be practically radial near the apex, as Fig. 11A shows; while the bands of colour, marking the stress difference intensity, are approximately arcs of circles with centres on the line of load and all passing through the apex. This is shown by the experimental curves of Fig. 11B, which correspond closely to the dotted circles fulfilling the conditions stated above. If, however, the material at the apex becomes plastic, there is a redistribution and equalisation of the stress in the crushed area. The colour bands immediately below are found to be approximately parallel to the line of demarcation between the elastic and plastic material, and for some considerable distance below, the bands are larger in radius, owing to the redistribution effect above.

When the load is slightly unsymmetrical the lines of principal stress in the elastic region appear to remain fairly radial and concentric with the point of application, and the colour bands of stress difference still remain approximately circular arcs with centres lying all on one line passing through the axis, but this line is now inclined at a considerable angle. This is shown by Figs. 12A and 12B, in which the direction of the applied force is inclined at 5 deg., and the experimental curves are easily seen to be of the type described, except for a small area close to the apex. For still greater inclinations of the applied force the same general characteristics are observed as Figs. 13, 14 and 15 show, and in the two latter cases it is worth noting that a dark radial band appears on the right, indicating no stress in this region, as subsequent measurements verify. There is, moreover, reason to suppose in these latter cases that the lines of stress are not quite of the same type as before, since the isoclinic lines are distinctly curved in the neighbourhood of the apex.

The stress effects in a wedge when loaded in this manner are shown in Fig. 15C, in which the specimen is viewed in circularly polarised light, so that only the colour effects are visible and the isoclinics do not appear in the photograph. It would be noted that the extreme point of the wedge had been rendered plastic by the vertical load applied, and was therefore opaque. The colour bands immediately below this region are therefore not circular arcs, since the plastic stress in the material just above causes a change in the loading of the contiguous layer below. Well away from this region however, the bands resume their circular arc form.

For convenience of experiment, measurements of the stress distribution were taken along the direction of the line of load only, and the values of $(p - q)$ so measured, are shown in Table I below, and are compared with stresses calculated from a theoretical treatment of the problem due to Michell.* It will be convenient here to sketch briefly this theory, in which a force P, Fig. 16, is applied to a wedge of angle γ, and making an angle ϕ with one edge. Let ox be a line of reference passing through the apex and making angles α and $\alpha - \gamma$ with the two sides of the wedge. Then on the assumption that there is only radial stress in the wedge, of the type

$$\widehat{rr} = -2c\frac{\cos\theta}{r},\quad \widehat{r\theta} = \widehat{\theta\theta} = 0.$$

The total component of the stress system along the line ox is

$$\int_{\alpha-\gamma}^{\alpha} \widehat{rr}\,.\cos\theta\,.\,r\,.\,d\theta = -2c\int_{\alpha-\gamma}^{\alpha}\cos^2\theta\,.\,d\theta =$$
$$-c\{\gamma + \cos(2\alpha-\gamma)\,.\,\sin\gamma\},$$

and in a direction at right angles is,

$$\int_{\alpha-\gamma}^{\alpha} \widehat{rr}\,.\sin\theta\,.\,r\,.\,d\theta = -c\int_{\alpha-\gamma}^{\alpha}\sin^2\theta\,.\,d\theta =$$
$$-c\{\sin(2\alpha-\gamma)\,.\,\sin\gamma\}.$$

These values enable the direction of the force P, at the apex, to be determined, since

$$\tan(\alpha-\phi) = \frac{\sin(2\alpha-\gamma)\,.\,\sin\gamma}{\gamma + \cos(2\alpha-\gamma)\,.\,\sin\gamma},$$

or

$$\tan\phi = \frac{\gamma\sin\alpha - \sin\gamma\,.\,\sin(\alpha-\gamma)}{\gamma\cos\alpha + \sin\gamma\,.\,\cos(\alpha-\gamma)},$$

which may also be expressed in the equivalent form

$$\tan\alpha = \frac{\gamma\,.\,\sin\phi - \sin\gamma\,.\,\sin(\gamma-\phi)}{\gamma\cos\phi - \sin\gamma\,.\,\cos(\gamma-\phi)}.$$

These expressions show that the maximum radial stress in a wedge subjected to a load at the apex does not in general coincide with the line of direction of the force,

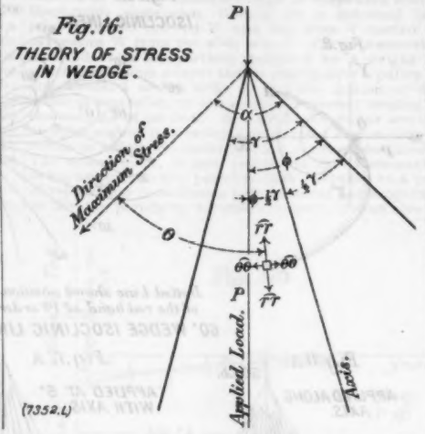


Fig. 17. STRESSES ALONG LOAD LINE OF 60° WEDGE, FOR MATERIAL ⅛-INCH THICK AND APPLIED LOAD OF 50 LB. WHEN THE LOAD IS APPLIED IN DIFFERENT DIRECTIONS.

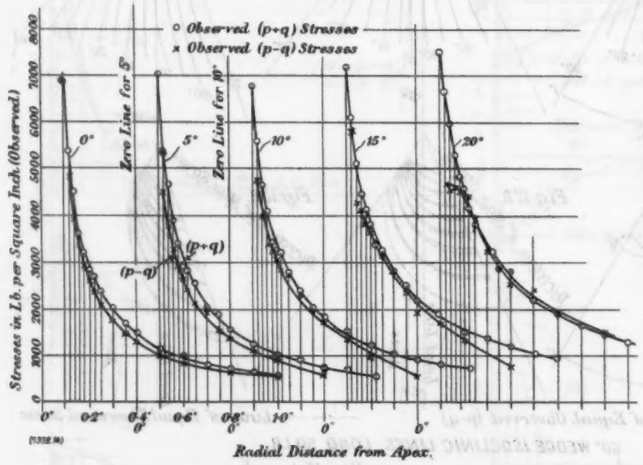


Fig. 18. STRESSES ALONG LOAD LINE OF 60° WEDGE.

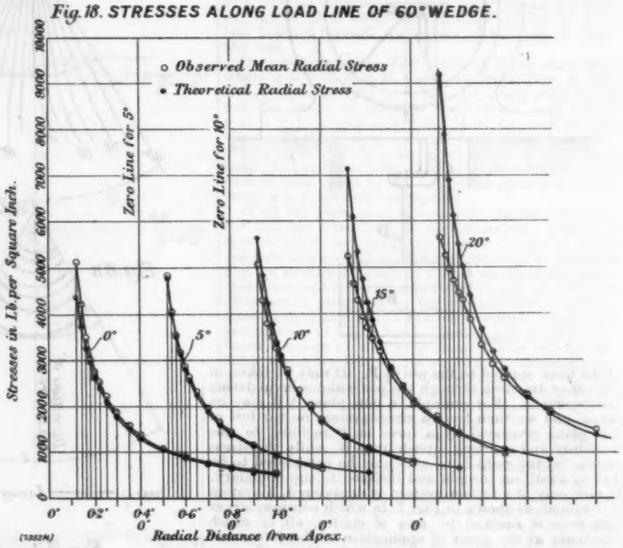


TABLE I.—TABLE OF STRESSES ALONG LOAD LINE OF 60 DEG. WEDGE.

Thickness = ⅛ in. Load = 50 Lb.

	r	0·12 In.	0·14 In.	0·16 In.	0·18 In.	0·20 In.	0·22 In.	0·25 In.	0·30 In.	0·35 In.	0·40 In.	0·50 In.	0·60 In.	0·80 In.	1·0 In.
$\phi - \frac{1}{2}\gamma = 0°$	$\widehat{rr}$	4,370	3,750	3,280	2,910	2,620	2,380	2,100	1,750	1,496	1,310	1,046	873	654	523
	$p - q$	4,870	3,920	3,320	2,896	2,626	2,380	2,090	1,740	1,500	1,296	1,020	830	616	—
	$p + q$	5,400	4,550	3,650	3,200	2,850	2,700	2,370	2,020	1,700	1,500	1,160	950	700	—
	p	5,135	4,235	3,485	3,048	2,738	2,540	2,230	1,880	1,600	1,398	1,090	890	658	—
	q	265	315	165	152	112	160	140	140	100	102	70	60	42	—
$\phi - \frac{1}{2}\gamma = 5°$	$\widehat{rr}$	4,765	4,000	3,500	3,110	2,800	2,540	2,240	1,860	1,600	1,400	1,120	933	700	560
	$p - q$	1,470	3,750	3,250	2,900	2,580	2,410	2,180	1,920	1,540	1,306	1,106	840	570	—
	$p + q$	5,200	4,440	3,900	3,460	3,150	2,850	2,500	2,060	1,780	1,560	1,260	1,030	750	—
	p	4,835	4,095	3,575	3,180	2,865	2,630	2,340	1,990	1,660	1,433	1,183	935	660	—
	q	365	345	325	280	285	220	160	70	120	127	77	95	90	—
$\phi - \frac{1}{2}\gamma = 10°$	$\widehat{rr}$	5,610	4,810	4,210	3,740	3,360	3,060	2,690	2,240	1,940	1,680	1,345	1,120	842	673
	$p - q$	4,780	3,970	3,480	3,260	3,080	2,860	2,710	2,310	1,980	1,680	1,310	970	564	—
	$p + q$	5,400	4,630	4,120	3,740	3,440	3,160	2,800	2,400	2,060	1,800	1,450	1,200	900	—
	p	5,090	4,300	3,800	3,500	3,260	3,010	2,755	2,355	2,020	1,740	1,380	1,085	732	—
	q	310	330	320	240	180	150	45	45	40	60	70	115	168	—
$\phi - \frac{1}{2}\gamma = 15°$	$\widehat{rr}$	7,150	6,100	5,350	4,760	4,280	3,900	3,420	2,850	2,450	2,140	1,710	1,430	1,075	856
	$p - q$	5,840	4,280	4,120	3,800	3,670	3,440	3,210	2,770	2,340	1,940	1,780	1,306	770	—
	$p + q$	5,800	5,000	4,500	4,100	3,800	3,530	3,200	2,830	2,500	2,230	1,800	1,530	1,180	—
	p	5,820	4,640	4,310	3,950	3,735	3,485	3,205	2,800	2,420	2,085	1,790	1,418	975	—
	q	−20	360	190	150	65	45	− 5	30	80	145	10	112	205	—
$\phi - \frac{1}{2}\gamma = 20°$	$\widehat{rr}$	9,200	7,900	6,900	6,140	5,520	5,020	4,420	3,680	3,160	2,770	2,210	1,840	1,380	1,105
	$p - q$	4,660	4,580	4,600	4,500	4,400	4,400	3,960	3,260	2,860	2,540	2,410	1,940	1,500	—
	$p + q$	6,680	5,950	5,350	4,900	4,540	4,230	3,800	3,330	2,920	2,600	2,180	1,870	1,460	—
	p	5,660	5,265	4,975	4,700	4,470	4,315	3,890	3,295	2,890	2,570	2,295	1,905	1,480	—
	q	1,000	685	375	200	70	−85	−80	35	30	30	−115	−35	−20	—

* Proceedings, London Mathematical Society, vol. xxxiv, 1902. See also Love's "Theory of Elasticity," second edition, pages 208 to 209, which is substantially followed here.

and they afford a means of determining both the direction and intensity of the stress at the cutting edge, if this can be assumed as acting at the apex of the tool, since γ is known and ϕ can be determined from observations of the colour bands. The direction of the force at the cutting edge can therefore be calculated, and its magnitude can be measured from the colour band distribution.

It may also be noted that the value of the force P at the apex is given by the expression

$$P = c\sqrt{\{\gamma + \sin\gamma \cdot \cos(2\alpha - \gamma)\}^2 + \{\sin\gamma \cdot \sin(2\alpha - \gamma)\}^2},$$

while along the load line

$$\theta = \alpha - \phi \text{ and } \widehat{rr} = 2c\,\frac{\cos(\alpha - \phi)}{r}.$$

TABLE II.

$\phi - \frac{1}{2}\gamma$.	0°	1°	2°	5°	10°	15°	20°
ϕ ..	30°	31	32°	35°	40°	45°	50°
α ..	29° 52′	40° 36′	52° 4′	72° 46′	91° 50′	100° 34′	105° 32′
$\alpha - \frac{1}{2}$ ..	0°	10° 36′	22° 4′	42° 46′	61° 50′	70° 34′	75° 32′
$\alpha - \phi$ ..	0°	9° 36′	20° 4′	37° 46′	51° 50′	55° 34′	55° 32′
$\frac{C}{P}$ ..	0·523	0·532	0·564	0·708	1·090	1·513	1·953
1,000 $\frac{C}{P}$							
$\cos(\alpha - \phi)$	523	524	530	560	673	856	1,105

Table II shows the magnitudes of the angles concerned in all the cases examined, and the last line gives the stress in a wedge 0·1 in. thick at a point in the load line 1 in. below the apex when the load P is 50 lb.

From these values the directions of the lines can be determined along which the centres of the arcs of stress difference lie, and they are shown in Figs. 11 to 15, and marked "directions of maximum stress." The dotted curves drawn with reference to these lines thus show the theoretical distribution, and, as will be observed there is a very fair agreement between them. If we now turn to the measured values of stress distribution the agreement is not so close, as Table I shows, especially near the apex, but since plastic stress occurs in this region a fair agreement cannot be expected there.

The measurements indicate the presence of transverse stress, and in order to show this graphically the stresses $(p - q)$ are plotted in Fig. 17, for all five cases of loading, so that the values of 2 q observed are shown as horizontal intercepts between the curves $(p - q)$. It is then seen that, except in cases of somewhat oblique loading, the values of q are relatively small, and one is inclined to ascribe their presence to bending effects, especially when $(\phi - \frac{1}{2}\gamma)$ is large, as although the experimental curves for these two last cases are very close together, the values of p do not agree with the calculated values of $\widehat{rr}$ as well as in the earlier cases.

This is more clearly shown in the next diagram, Fig. 18, in which the values of p, which lie along curves midway between those shown on Fig. 17, are compared with the calculated values, and it is then seen that the agreement between them is a very good one for the first three cases, but discrepancies are observable for $\phi - \frac{1}{2}\gamma = 10$ deg., which become still greater for $\phi - \frac{1}{2}\gamma = 15$ deg. and 20 deg. It is possible that with a very thick plate of material these differences would be smaller, but the authors have not been able to secure sufficiently good and thick plates of nitro-cellulose in order to make such a test. On the whole the tests may be regarded as an experimental confirmation of the theory of stress distribution at the apex of a wedge, and if this may be taken for granted it introduces a considerable simplification in further work on the action of cutting tools by this method, since the stress distribution on this assumption can be inferred from the colour bands alone, without the necessity of lateral measurements, and only one point of the colour band needs calibrating in order to obtain the stress at any point of it within the elastic region of the tool. It appears possible that the distribution nearly up to the point of cutting edge can be also determined in this manner, and the sum of all the forces acting on the tool expressed approximately as a single force acting at this edge.

The actual distribution over the limited area of contact between the work and the tool can be found experimentally by measuinrng $(p - q)$ and the isoclinic lines at the edges, and this appears to be feasible, although it is clearly a matter of difficulty.

It is possible that the account given here of the distribution of stress in a turned disc may be helpful in forming an idea of the kind of stress which occurs in a cylinder when a cut is taken along it, but it is clear that the stress system so produced is not nearly so simple as in the disc, while in both cases the distribution of stress in the plastic region in the work, the tool and the shaving presents problems of a higher order of difficulty, which the authors venture to suggest as of immediate importance to the committee.

MESSRS. ARMSTRONG AND WATER POWER.—In May, 1920, Sir W. G. Armstrong, Whitworth and Co., Limited, initiated a hydro-electric section for water turbines. The volume of business laid before the section has led the Board to form a separate hydro-electric department, as from January 1, 1922. The new department, like the former section, is dealing with complete water power development schemes throughout all the various stages, no less than with the various component parts of such schemes, civil engineering, mechanical and electrical. Messrs. Armstrong now have survey parties out in many parts of the world looking into projects which have been brought before them for submission to the powerful financial group with whom they are working in London.

SOME POST-WAR PROBLEMS OF TRANSPORT.*

By SIR JOHN AUDLEY FREDERICK ASPINALL, Past-President Inst. C.E.

WHEN the Council did me the honour of asking me to write the "James Forrest" Lecture for 1922 on Transport, I felt a difficulty, as so much has already been written on this important subject, and it was almost impossible to say anything which was not already in the hands of those who take an interest in this subject. Therefore I must ask the indulgence of our members if I fail to make my subject as interesting as I would wish. Transport problems have undoubtedly become of much greater interest to the majority of our citizens since the war, partly because such a large proportion of our manhood had opportunities of seeing how much these questions affected the progress of our armies, and, again, because of the paramount necessity of economy in everything which affects the productive power of the nation. There is no section of our citizens which has not an interest in the economical transportation of the passenger, and all are affected in some degree by the cost of the carriage of goods as bearing on the price of the commodities they consume, though the merchants and manufacturers, who have to pay away large sums for carriage, have this question of cost brought home to them in a more wholesale way.

In addition to the question of cost, there has been a demand on behalf of the town dweller that he shall be given additional facilities to get away easily and cheaply into a better atmosphere, and the genuine desire to find healthy dwellings for the working-classes has made it imperative that our facilities for travel shall grow on a generous basis, consistent with an adequate return to those who provide them.

LONDON PASSENGER TRAFFIC.

The ever-increasing growth of London makes it necessary to look forward to the time when greater facilities will exist for taking the teeming population to and from work. The lay-out of the railways in the early days was hardly considered from the point of view of the short-distance passenger and the location of the stations, and the methods of approach of the lines themselves all point to the fact that it was expected that the passenger travelling some distance had alone to be catered for.

It was only by degrees that the growing demand of the suburban traveller became so insistent that means of some kind had to be found by the main line railways for dealing with a traffic which the original designers of the line had never anticipated. Under these circumstances it is very creditable that they should have been able to get over the immense difficulties involved.

Other lines of way have, however, in modern times been added for this local traffic, and the notable addition of the tubes has, with their very effective management, enabled many thousands per day to be carried with comfort and rapidity. It may be of use to glance at some of those detail points which help travel.

CONSTRUCTION OF CARS AND STATIONS.

Michael Angelo once said: "Little things make perfection, little things mar perfection, and little things are the greatest part of perfection." This saying is specially applicable to methods of dealing with suburban traffic, and some of the points I mention below are worthy of consideration, more particularly with regard to tube railways.

The methods of approach to platforms is of great importance, and those most modern stations where we find the escalator starting from the street level and leading down to platform level between the two platforms, are examples of careful design which are a vast improvement on those older stations where people have to pass upstairs and downstairs and through lengthy and tortuous passages before they reach the train. The presence of plain directions well lighted, and placed in positions which ensure their being seen, saves much time. All travellers in the tubes have grown so accustomed to them that when they arrive at some stations on the older tubes, where they do not exist, or have been less carefully considered, these useful guides are at once missed and give rise to thoughts of there being less efficiency.

The construction of the carriage stock has an important bearing on quick loading, and it seems to be eminently desirable that when a passenger enters a car he should be able instantly to see when there is an unoccupied seat to which he can go. High backs to seats which interrupt the view, and other obstructions to a clear view, may waste valuable seconds. It is a mere Utopian vision to hope that the seating room can ever be so ample that strap-hanging will be abolished in rush hours, and it therefore becomes necessary to consider how the strap-hanger can be accommodated in such a way as to make his standing position as comfortable as possible, and yet arrange that he shall not stand in the way of movement of others. The holding-on devices appear to be of two orders, the usual strap and the iron pillar. The latter is of more recent use, and appears to be less desirable than the former. The pillar results in groups of persons standing around it and holding on to it, and forming considerable obstruction in the middle of the car, whereas the older form of strap results in a long line of passengers on each side, leaving a space, however narrow, between the two lines. The pillar arrangement is also an obstruction to circulation, and pillars are uncomfortable to bump up against.

The number of doorways on the side of a car and their width, whether for one file or two files of passengers, are points not only of importance to the traffic superintendent, but also to the carriage builder, who does not want to weaken the structure unduly by cutting away the sides. The necessity of quick loading and unloading of a car means that the doorway arrangements has to be considered, and, as in most cases, the stream of ingoing passengers has to wait until those outgoing have passed out, there is a great deal of delay which might be avoided if stations were constructed differently. This trouble of loading and unloading can very largely be got rid of by spending more money on new stations and putting in three platforms instead of two. It is then possible to load all passengers on the near side of the trains at the side platforms and to unload them all at the off side at a central island platform. Passengers can then begin to enter the train the instant it stops and do not conflict with those going out, and several seconds per stop can be saved. The stream of outgoing passengers from both up and down lines on the central platform can pass out without obstructing those joining the train. The greatest possible attention should be paid to the continuous flow of passengers, and all steps taken to prevent any interruptions of the flow by dividing the incoming and outgoing streams.

The question of dealing in a comprehensive way with London traffic is one which has been spoken of by so many people, and so many divergent views have been expressed, that it looks as if we want a dictator to lay down certain definite broad lines on which future development should take place. The information which has been gathered together on the subject, and the immense amount of investigation and research which it has involved, are to a great extent thrown away if they are not made use of by some authority which has or should have the power to deal with co-ordinated schemes.

Very carefully thought-out plans have been prepared by the tube companies for extensions both south and north of London, and also for additions to the existing lines within the most populous routes of to-day. In those places where traffic density is greatest, proposals have been considered for running new tubes at a lower level beneath the existing ones, with fewer stations, thus supplying the demand for quicker long distance travel. These plans seem to indicate a very close study of the difficult questions involved, and to demonstrate the great value of any extensions being linked up with the existing systems.

It is unfortunate that the incidence of the war disturbed the systematic collection of information which we used to receive from the excellent reports of the London traffic branch of the Board of Trade, and therefore figures which might be quoted are somewhat out of date; but the diagrams which were issued with these reports (Cd. 0608) showed so clearly the way in which traffic by road and rail flowed into London that I considered they would be of interest to many members, though those concerned with London traffic are familiar with them, and I have to thank His Majesty's Stationery Office for permission to extract and make use of the information they gave, though presented here in a modified form. Fig. 1, page 570, shows how the stream of railway passengers arrives in London by our railways other than the tube lines. The areas hatched with hard lines indicate the flow of ordinary passengers, while the areas faintly hatched indicate passengers using workmen's tickets. It is thus possible to see which companies are affected by this latter unremunerative traffic. The general effect of the diagram is to show how large is the traffic in certain directions, notably towards the east, and how it appears likely that in the future provision will have to be made for London's growing population to live, and therefore to travel, in those directions—north-west and south-west—which have as yet much more blank travel space on the map.

A study of these diagrams indicates how some of the railways have to bear the brunt of the rush hour passenger traffic, while others are at present called upon to carry a lesser traffic, and it may be that this is fortunate as it indicates the districts which ought to be filled up with dwelling houses. The road traffic diagrams point in the same direction. It will be observed how the traffic begins at each extremity of the star, as a tiny trickle, growing greater with swelling volume as it approaches London, but not so difficult to deal with as it does not all come at once, as different employments call for different hours of starting owrk. In the evening, however, the flood of return demands different treatment, coming as it does with a rush when the terminals and the train capacity are taxed to the utmost. It is true that the greatest possible frequency of trains becomes absolutely necessary, and so crowded out are the eastern stations of London, that the saving of seconds becomes of importance, and the spending of minutes seems an extravagance. Admirable as may be the organisation which cuts down the time spent in steam operation of suburban trains, it would appear as if London traffic can henceforward only rely on electrification to supply the ever-increasing demand for great frequency of trains, coupled with adequate seating capacity in the most modern rolling stock.

Fig. 2 shows how closely the vehicular traffic on the chief roads follows the same lines as the railway traffic, affected, as it naturally is, by the density of population. In this case the areas hatched with hard lines represent trade vehicles, and those with faint lines the passenger vehicles. The figures from which this diagram was prepared must, however, have grown enormously owing to the increase of motor traffic of both kinds. This increase of figures does not, however, affect the direction of flow. Meanwhile, the railway traffic is helped by the ubiquitous motor 'bus. How great a part the motor 'bus has taken in carrying the London public is indicated by the fact that, in 1921, the London General Omnibus Company

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* The "James Forrest" Lecture, 1922, delivered before the Institution of Civil Engineers, Tuesday, May 2, 1922.

handled 761,250,000 passengers, which is just about one-half of the figure shown for all the railways of Great Britain, who, in the most recent returns, for 1919, sold 1,577,194,497 tickets to ordinary passengers and workmen. While the passenger mileage on all those railways was 227,397,359, the 'buses ran 87,000,000 miles, so that, by running about one-third of the railway mileage, the omnibuses picked up about half as many ticket-purchasing passengers as all the railways carried in this country, with their much more expensive organisation and equipment.

The improvement of the motor omnibus has been so great, and its capacity for handling very large volumes of traffic has so recently been demonstrated, that it is safe to assume that the much more expensive tramway system will not be extended to any great extent. The rigidity of the tramway system compared with the great flexibility of the omnibus services, which enables passengers to join at the curb, will always tell against a vehicle which must run in a fixed position on the road, and which involves much greater risk of accidents to those who step on or step off. Notwithstanding this great capacity for handling traffic possessed by the most modern omnibuses mainly for dealing with very short distance traffic, the extension of railway facilities for London is an urgent necessity. The capacity of a train carrying 400 to 500 people, with such trains succeeding one another at intervals of about 1½ minute, is required to deal with the rush of travellers morning and evening, most of whom are showing more and more desire to get well out of London, encouraged thereto by frequent and well-lighted trains, so that they forget the minutes of travel when reading their evening papers.

Records show that the engineering world has not been backward in proposing new means of dealing with London traffic, and I have before me as I write two maps prepared by an eminent firm of London engineers, which show in detail all the very numerous propositions for new lines which were made first between 1855 and 1885, and next between 1885 and 1903. There are still later propositions, but if we take those only up to 1903, they form a picture for the main part, of failure, of costly effort, in designing, in promoting, and in bringing before Parliament, and certainly point to the desirability of co-ordinated effort in the study of this most important problem. The above schemes represent an enormous waste of money, not because the schemes in themselves were bad, but to a great extent because our methods of private bill legislation often result in the defeat of well-planned proposals on grounds which subsequent events prove to have been unsound. I should not despair of some first-rate scheme being adopted for future gradual development if it were on the first instance considered and proposed by a strong committee of those who are engaged in handling London traffic to-day, and then legalised, with a view to its being financed and carried out in sections. A scheme would be created in the minds of the committee, who should be men with a very full knowledge of the flow of traffic, in such a way as to dovetail in with existing routes in the most economical way for operation, and with a keen eye to public requirements. Hitherto so much harm has been done by dealing with this problem in bits, that it becomes the more desirable to deal with it as a whole, without preventing in any way future additional proposals which the growth of London may demand.

So far as it is possible, it would be well that new lines should be interwoven with existing routes, and continuous travel arranged for without change of train. Any prolongation of existing lines outwards from London will be worked more economically if the double line of railway circles round the final position in the country district and runs towards the city by another route. This would result in there being two routes to the same outlying district, giving facilities to two sets of travellers and building up a traffic to the farthest point which will make the extended facilities more profitable. A third diagram (Fig. 3, page 572) indicates where the greatest densities of traffic are to be found in London, and the rectangular blocks, which are hatched with hard lines to show trade vehicles and fine lines to show passenger vehicles, enable one to appreciate at once what are the proportions of the respective traffics. They are of especial interest as showing what the bridges across the Thames have to carry, and how a bridge like the Tower Bridge is almost wholly occupied with trade vehicles, while Westminster Bridge takes the largest proportion of passenger vehicles. The traffic over the old Southwark Bridge shows how the old gradients reduce the flow, and when we look at the density over Blackfriars Bridge it at once shows the necessity for proceeding with St. Paul's Bridge, which has been postponed so often.

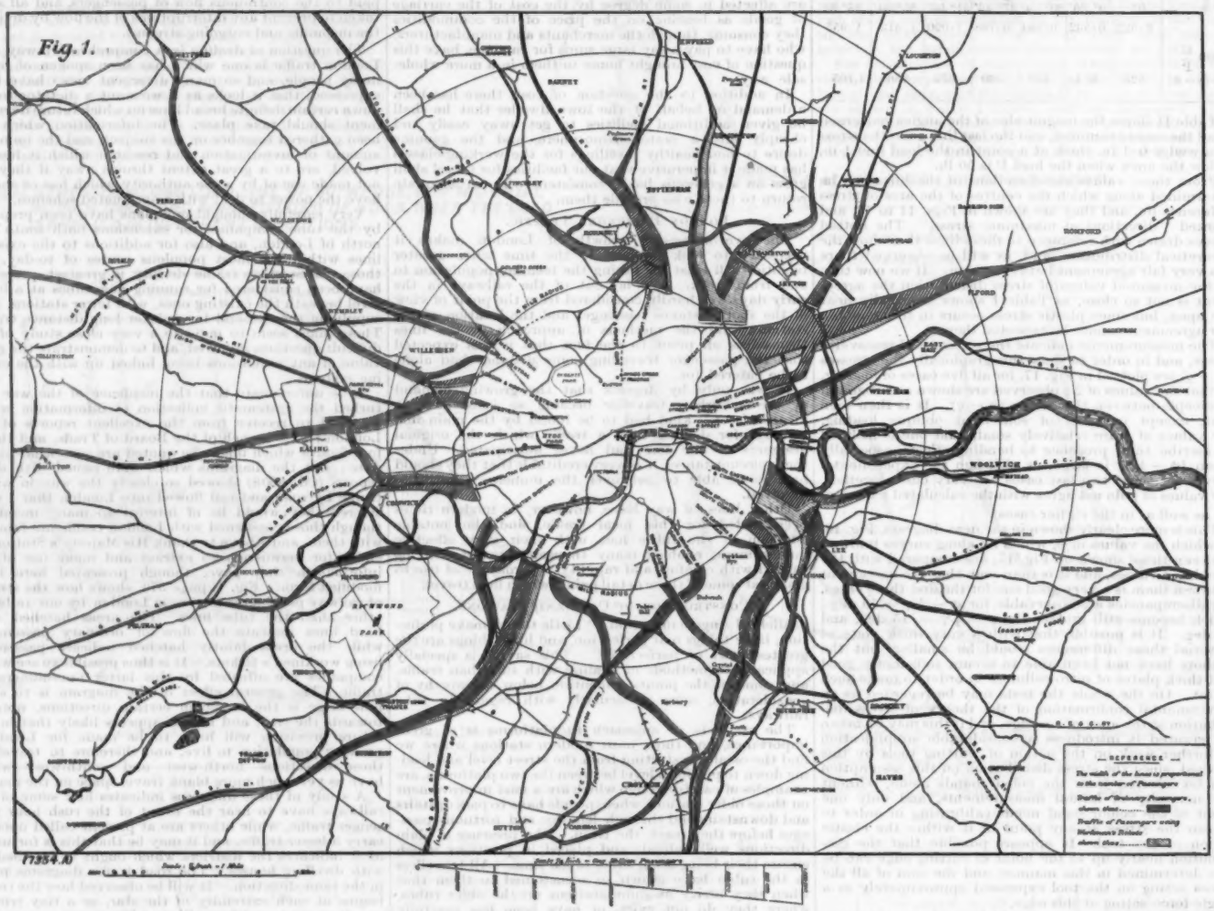
We have repeatedly seen great objection raised in the Press, mainly on architectural lines, to the continued existence of certain railway bridges across the Thames. It is sometimes forgotten that the number of people who are carried across them in trains in 24 hours far exceeds the number of those who could pass over an ordinary road bridge, and, therefore, if their desirability is to be measured by the value of their use to the general public, a much larger number of the public would be inconvenienced by their abolition than those who would gain by additional road facilities. The objection to them on account of unsightliness is a legitimate complaint capable of being got rid of, but their abolition would be a very distinct loss to the travelling public.

The fact is that London is so big and grows so rapidly that no abolition of existing facilities for transit ought to be permitted. Nearly 692 square miles of land are within the Metropolitan Police area, and within this space is a population of 7,476,168 people. They require not only all the facilities for crossing the Thames which exist, but more, either under or over. Charing Cross railway bridge, for example, has been the butt for much satirical comment, and the company that owns it has been subjected to many stringent regulations should they endeavour to improve it for traffic purposes. There is, however, a plan which has not yet reached the public eye, by which it seems possible to satisfy æsthetic taste, to provide for road requirements, and still enable a bridge to be used for railway purposes.

A well-known engineer has shown how a double-decked bridge can be constructed with all those architectural features with which our architect friends desire to ornament the creation of the engineer. In this proposition the railways can be allowed to cross at the same level as now, and thus not interfere with the water-borne traffic on the Thames, while the roadways carried at a higher level are designed to descend with easy gradients so as to join up with the Strand and also with roads on the Surrey side.

It is part of this wholly unofficial proposal that, instead of Charing Cross station remaining at its present level, the railway, after crossing the Thames, should dip down somewhat and continue as a station in a suitable position mainly for local traffic. Nearly all main line traffic could be dealt with on the Surrey side, probably at Waterloo. There is little doubt that, if the great grouping of railways which is taking place could have been foreseen, Waterloo Station, which is undoubtedly the finest station in London, would not have been built exactly in the present position. As the London and South-Western Railway, the South-Eastern and Chatham Railway, and the Brighton Railway are to form one group, there are certain services of trains from each of these systems which could, with advantage, have been run into Waterloo by making a series of junctions outside, which are not difficult to arrange. Possibly Waterloo Station could even now be made the point of departure and arrival for Continental services from the three systems, provided that the electric services now running into the station were found accom-

Fig. 1.



modation elsewhere. That these local services would be much better dealt with by an arrangement of lines which ended in a loop, so that there would be no crossing of incoming trains by outgoing trains, is, I think, generally admitted, but it involves considerable expenditure, which is possibly justified on account of the ever-increasing flow of traffic. So far as we have gone in the past it seems to be true that passenger traffic facilities have never been in advance of requirements, and that a new local train service almost immediately fills up.

Main Line Railways.

A very great change has come over the railway system of this country since the war, and it is common knowledge that by the end of this year all the railways will have been united by law into four great groups. The general idea of grouping has been that economies may result, and very great expectations have been raised as to the magnitude of these possible economies. The modern view that judicious combination will lead to better results than excessive competition was anticipated by our Past-President Robert Stevenson, who told a Parliamentary Committee in 1846 that, "Where combination is practicable, competition is impracticable," and "Perpetual competition is impossible, and that after the country is occupied there will be an adjustment." It must, however, be remembered that the labour costs, both in relation to time worked and wages paid, have soared to a height which no one could have anticipated. Before the war railway wages cost 47,000,000*l.* per annum. Since the decreases in time and the increase in pay which were given by the Government the costs rose to 165,000,000*l.* in January, 1921. It is true that under a sliding scale governed by the cost of living there have been reductions of pay which mean 25,000,000*l.* in the aggregate, but the gross figure of expenditure is so much above pre-war times as to jeopardise an early return to a reasonable dividend-producing basis. Added to all this comes the additional cost of coal and the higher prices of nearly all materials when compared with 1913, which is estimated at about 60,000,000*l.* Two diagrams, produced by Sir George Beharrell, showing in circles, which are to scale, what was the expenditure of railways in 1913 and what it became in 1920, are given in Figs. 4 and 4A, page 572. There are still, therefore, some stupendous figures on the wrong side which exist ready to swallow up most, if not all, of the economies which it is possible to create, before the time arrives when the charges to railway users can be so reduced as to make a substantial difference in the cost of carriage in this country. The interesting thing, however, to engineers is to see how far it is possible for them to assist in producing economies, and whether these in the aggregate are likely to save such large sums as to affect materially the serious increases I have mentioned.

The statistical returns as to railways, which nowadays are published every month by the Ministry of Transport, give very large numbers of figures affecting many aspects of railway work, from which I pick out a few only of the leading items, which in themselves are a measure of working efficiency. The railways up to the middle of August last were still subject to control, and there were so many matters being handled in a manner which was out of the ordinary course, that the statistical figures before that date are of less value than those of the following months, when the various companies began to get back into their stride. Selecting, however, a recent return (No. 24) for the month of November, 1921, we find that the average length of haul was 55·6 miles, which is a good indication of the short distances we run in our small country. This figure is an average of both general merchandise and minerals, including coal and coke, though if general merchandise is taken alone the figure becomes 88·69 miles. The average freight train load works out to 126 tons, which looks exceedingly small when we are aware of the numerous trains on many English railways which have train loads of from 1,000 tons to 1,200 tons. The low figure merely indicates how any average which brings in railways, great and small, does not show the real progress which has taken place.

The advent of more powerful locomotives, whether steam or electric, and better wagon loading, would have a material effect in increasing this figure. In handling this freight service, all steam locomotives consumed an average of 63·15 lb. of coal per freight engine mile, while the passenger service took 49·64 lb. per passenger engine mile. The above coal consumption shows also what work the 24,373 steam locomotives have been doing on the 51,315 miles of single track, including sidings, in Great Britain. It will be observed that these figures mean that there is about one locomotive to each two miles of single track. The steam locomotive mileage run per day for all locomotives, per engine in use, as distinguished from the number of engines in stock, is in the case of one company 117·76 miles per day, and while five others exceed 100 miles per day, the majority run but slightly over 90.

Interesting as these last figures are, they become more so when we find in another return that the same company which obtains the largest daily mileage out of its steam locomotives, the 117·76 referred to above, also obtains the large week-day mileage of 211·57 miles out of its electric motors, which are attached to its multiple unit trains, while other companies, other than the tubes, obtain 198·56, 177·61, 167·66, and 167·34 miles. This becomes at once a very practical illustration of the immense advantage of electrical operation which enables you almost to double the work of the mechanical unit, because the electric machine does not require those stoppages for changing engines or for coal and water and cleaning fires which are essential for the steam machine, and, provided lubrication is attended to, the electric machine can go on running for a great length of time if relays of men are provided. This point has become very prominent since Hobart, in his "James Forrest" Lecture of 1915, told us about the electrical locomotive work on the Chicago, Milwaukee and St. Paul Railway, as they are now making regular trips of 440 miles with one engine, and have secured an average mileage of 10,000 miles a month per locomotive.

All the points in favour of electrification have been so often put before the public that it would be mere repetition to deal with them again, especially as so recently as January last a paper, read before the North-East Coast Institution of Engineers and Shipbuilders by Sir Vincent Raven, which has been widely noticed, set out with minute care the arguments for and against main line operation; but I think I may again call attention to the most important fact that the train capacity of any railway, and particularly of any terminal station, is vastly increased, and thus the capital cost of extensions and widenings can be postponed for many years. One of the advantages of hauling express trains of considerable speed with electric locomotives is that extreme variations of speed are avoided. Where the first part of the journey starts on a heavy gradient the speed will be much higher than with steam, while the necessity for running down grade at high speed will be avoided and a better average speed obtained with little difficulty. The very fact of getting away from terminals rapidly will assist in clearing the line at a point where generally the congestion is greatest. In many cases electrification will cost much less money than widening.

We find that other countries are moving ahead quite rapidly. The South African railways are electrifying 170 miles of track as a first instalment. In Chile 128 miles of line have been selected for immediate equipment. The French railways have ordered numerous electric locomotives, and have adopted continuous current with a pressure of 1,500 volts, which corresponds with that advised in this country by the Electric Railway Advisory Committee. Switzerland and Italy are quickly progressing, but Japan, New Zealand and Australia are all doing something, and, as to the United States, we have all read of their progress. The Government having accepted the report of the Electric Railway Advisory Committee (1921), that future electrification of railways should be carried out with a system of continuous current at 1,500 volts, and having set out the information which should govern the position of conductors, one important reason for delay has been swept away.

In order to show what is being done and what has been done on the construction of electrical locomotives, I have given in the Tables on pages 572 and 573, in which are set out the principal dimensions and the power of some of these locomotives, which, it will be noticed, are spread over the world.

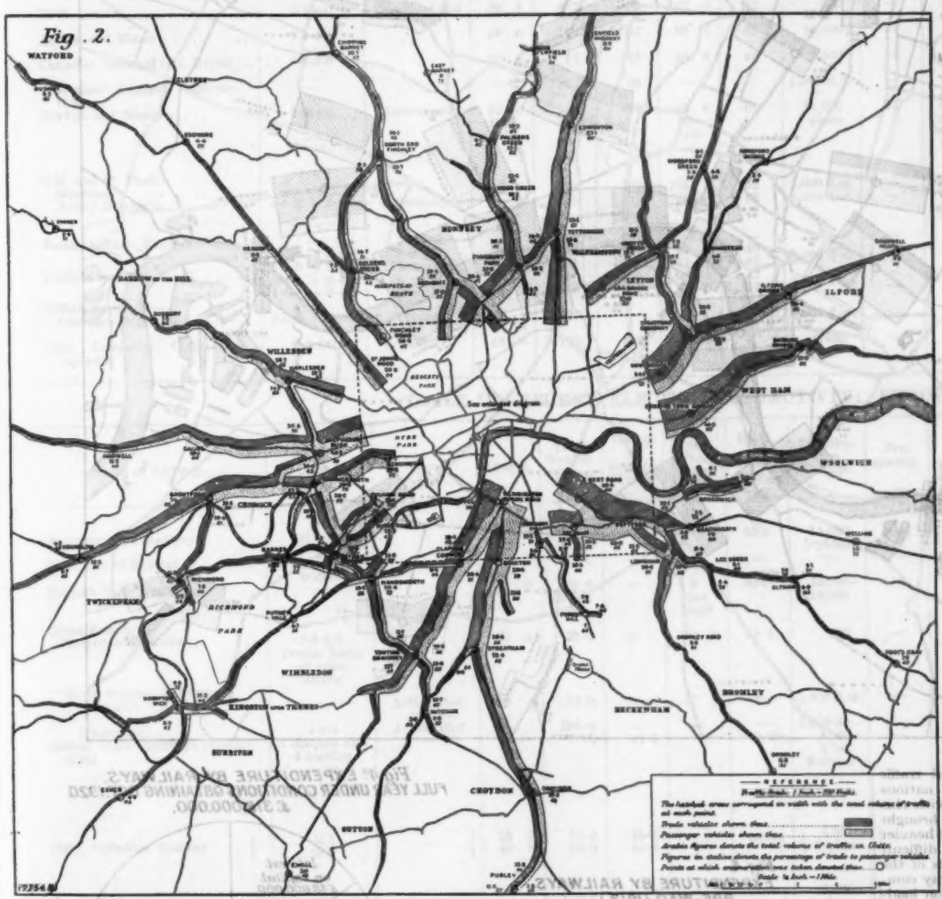
The question of the provision of capital has been largely made easier by the Trade Facilities Act, under which the Government can, within certain limits, give guarantees which enable money to be raised on reasonable terms. Already, in other classes of engineering, manufacturers are seeking to take advantage of this Act so as to export their productions to foreign countries, and some very large schemes are being considered. It is no doubt a great benefit to the engineering interests which are involved, and will, if these schemes mature, find much work in our industrial districts, but, once exported, this machinery will cease to produce anything for us here, whereas electrical railway plant, built and set up in this country, would not only create employment and bring profit to the makers, but would, when put to work, continue to be a wealth-producing plant, adding to the prosperity of our industries at home and creating new facilities.

No one now questions the great advantages of the electrification of suburban railways, but there is still hesitation and doubt as to the extension of electric working to main line traffic. I have no hesitation in saying, in the light of the most modern experience, that there are numerous cases in this country, if the district is carefully selected, where expenditure under this head would be found most remunerative, especially for goods trains, and it is a matter for regret that we move so slowly. While it is perfectly true that many cases can be cited where electrification should not be looked at for some years to come, there is no reason for postponing work which can be done now, with advantage to the workless, with profit to the manufacturer, with good financial results to the railways, and with great advantage to the travelling public.

Wagon Loads and Shunting.

Turning again to the statistical returns, we find that the average wagon load which is given for cases of sixteen companies, shows at once how the loading in each distric is affected by the question as to what are

Fig. 2.



the proportions of general merchandise and mineral traffic, the latter always leading to heavier loading. We find one company, which is a large carrier of coal and coke from Yorkshire to the extent of 68·56 per cent. of its tonnage, having only 17·24 per cent. of general merchandise in addition to some other mineral traffic, obtains an average wagon-load of 6·41 tons only, whereas when we get to South Wales where one company has 90·81 per cent. of coal and coke traffic, the average wagon-load is 10·28 tons. It is on this coal traffic with its small loading compared with other nations that we want a quick revolution, and I deal with this question elsewhere. Fortunately this could be brought about comparatively soon for export coal, but the heavier loading of general merchandise is a much more difficult problem, mainly on account of the retail habits of the trading community, which result in all the railway companies in Great Britain having an average wagon loading, including merchandise, coal, and minerals, of only 5·46 tons.

For the first time in the history of British railways the statistical returns enable us to see what is the shunting mileage of the railways as a whole, and you can grasp what a very large item of expenditure this represents. Selecting twelve consecutive months, we find that 288,000,000 freight engine miles were run in Great Britain, and that out of this 144,000,000 miles, or 50 per cent., were train miles representing remunerative work. Out of the other 50 per cent. no less than 117,000,000 miles were spent in shunting. The basis on which the returns are made up assumes 5 miles an hour for shunting work. This 5 miles an hour is made use of in sorting out and arranging all wagons, both railway owned and privately owned, and as the latter form about 50 per cent. of the total, they require about half of the work done. As the all-round cost of a locomotive now works out at about 10*s.* an hour, 14,250,000*l.* represents the cost of freight shunting, and forms about 20 per cent. of the total locomotive expenditure for running and repairs and renewals in this country.

The ultimate ownership of all wagons by the railway companies, added to the introduction of larger wagons, will eliminate a very large proportion of this shunting expenditure. The constant sorting and arrangement of the 614,127 traders' wagons, which have daily to be sent back to destinations, ordered by the 6,450 separate people who own them, is like the perpetual piecing together of a jig-saw puzzle with all the disadvantages of waste work. I consider that it is more than likely that when, in course of time, railway wagon ownership is completed by the railways, from 20 to 25 per cent. of the above large shunting costs will be saved, and that if each succeeding year sees the disappearance of, say, 26,000 to 30,000 private owners' wagons, a proportionate saving will be made. In the search for economy the above is a good illustration of the possible effects of a forward policy in wagon ownership, which is made more easy by the fact that the Ministry of Transport Act of 1919, Clause 13, gives all the necessary powers. Those who are interested in the study of railway figures, and who may possibly desire to point out where they consider that real economies can be obtained, have now an opportunity of studying each month the very voluminous figures covering 36 closely printed pages, from which I have merely extracted a few which seem to act as pointers to the main costs of the mechanical side of operative movement of freight, without dealing with that vast amount of hand labour to be found in our goods stations, much of which should be done by machinery.

The effect of grouping so many railways into each group will be that automatically, in course of time, there will be marked tendency to reduce the number of types of locomotives, and immense strides will be made in reducing the number of parts, bringing about that

Fig. 3.

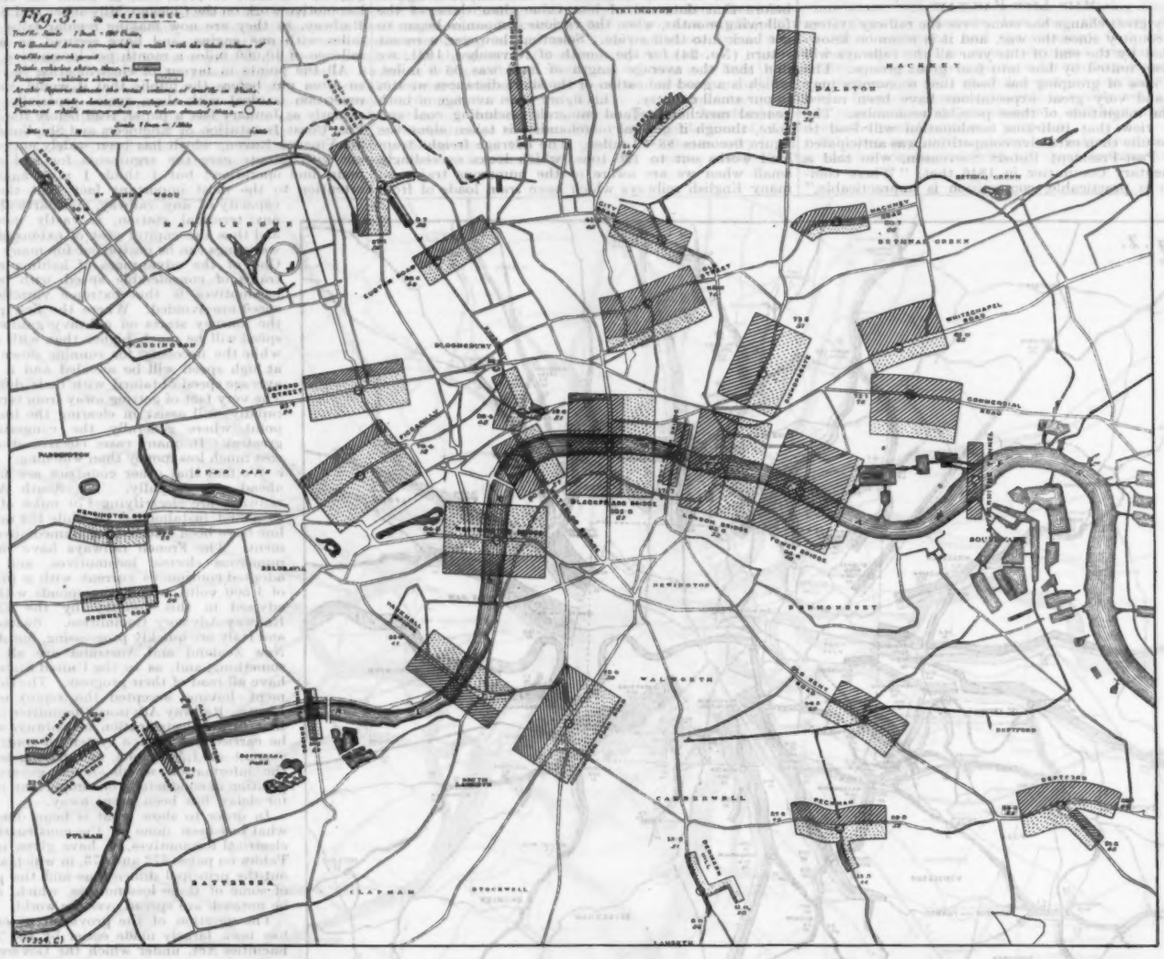
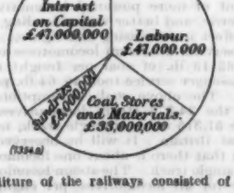


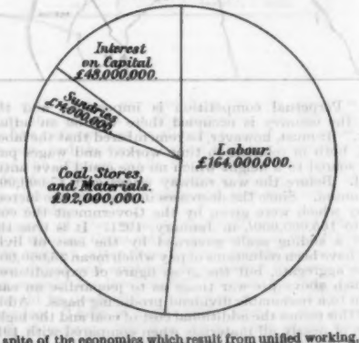
Fig. 4.
EXPENDITURE BY RAILWAYS.
PRE-WAR (1913.)
£135,000,000



The expenditure of the railways consisted of payments for:—

Labour	£47,000,000
Coal, stores and materials	33,000,000
Sundries	8,000,000
Total working expenses	88,000,000
Interest on capital	47,000,000
	£135,000,000

Fig. 4a. **EXPENDITURE BY RAILWAYS.**
FULL YEAR UNDER CONDITIONS OBTAINING OCT. 1920.
£318,000,000.



In spite of the economies which result from unified working, the estimated expenses based on present-day cost have increased to:—

Labour	£164,000,000
Coal, stores and materials	92,000,000
Sundries	14,000,000
Total working expenses	270,000,000
Interest on capital	48,000,000
	£318,000,000

SOME POST-WAR PROBLEMS OF TRANSPORT.

TABLE I.—RECENT ELECTRIC LOCOMOTIVES: AMERICA.

Name of Railway.	Class.	Type.	Length.	Total Weight. (Tons.)	Weight on Drivers. (Tons.)	Total Wheel Base.	Diameter of Driving Wheels.	Distribution Voltage.	Frequency.	Type of Motor.	Number of Motors.	Rated H.P. of Loco.	Transmission System.	Tractive Effort (Lb.).	Average Speed, M.P.H.
			ft. in.			ft. in.	in.								
N.Y., N.H. and Hartford ..	2-6-2 + 2-6-2	Passenger	69 0	156	104	59 6	63	11,000	—	—	12	2,550	Geared quill	21,000	45·6
N.Y., N.H. and H.	2-6-2 + 2-6-2	—	—	180	—	—	—	11,000 a.-c.	25	—	—	2,000	—	21,000	36·0
N.Y. Central and Hudson River	4-4 + 4-4	Passenger	56 10	119	119	46 5	36	600	—	—	8	2,600	Direct	20,000	44·5
Pennsylvania	2-6 + 6-2	Freight	76 6	230	196	63 11	72	11,000	—	—	4	4,800	Geared side rod	88,000	29·4
Pennsylvania	—	"F. F. I."	—	240	—	—	—	11,000 1-phase	25	—	4	4,800	—	—	10·3 & 20·6
Butte Anaconda and Pacific ..	0-4-4-0	"F. F. I."	37 4	72	72	26 0	46	2,400	—	—	4	1,280	Twin geared	30,800	15·4
Norfolk and Western	2-4 + 4-2	"F. F. I."	105 8	264	222	94 10	62	11,000	—	—	8	3,300	Geared	87,000	14·0
Mich. Central	0-4-4-0	Passenger and freight	39 6	107	107	27 6	48	600	—	—	4	1,100	Twin geared	34,000	12·3
Boston and Maine	2-4-4-2	,,	48 0	118	97	38 6	63	11,000	—	—	4	1,510	Geared quill	23,500	24·2
Canadian National (Mt. Royal)..	0-4-4-0	,,	37 4	75	75	26 0	46	2,400	—	—	4	1,280	Twin geared	20,200	23·4
Tidewater Southern Railway, U.S.A.	—	—	—	60	60	—	—	1,500 d.-c.	—	—	4	—	—	14,500	22·0
Norfolk and Western	2-4-4-2	Articulated	52 10 One unit	240	196	42 0 One unit	62	11,000 1-phase	25	Polyphase induction	8	3,280	Twin gearing and connecting rod	85,800	28·0
C.M. and St. Paul—															
Montana	—	—	112 0	252	200	102 8	52	3,000 d.-c.	—	—	8	3,440	—	55,000	15·25
Rocky Mountain	4-6-2 + 2-6-4	Articulated	—	265	229	79 10	68	3,000 d.-c.	—	Twin armature	6	4,200	Geared Spring	112,000	55·0
Pacific Electric Railway ..	—	Freight	—	57·5	—	—	—	—	—	—	4	1,000	—	30,000	25·0
Paulista Railway, Brazil	0-6-0 + 0-6-0	Freight	50 2	116	116	37 0	40	3,000 d.-c.	—	—	6	1,680	Geared	29,400	40·0
	2-4-0 + 0-4-2	Passenger	52 11	140	101	41 2	63		—	—	4	2,240		19,400	65·0
	0-4-0 + 0-4-0	Freight	39 2	100	100	26 8	42	3,000 d.-c.	—	—	4	1,680	Twin geared	30,600	28·0
	4-4-0 + 0-4-4	Passenger	55 0	120	80	46 0	42		—	—	4	1,680		15,680	53·0
Chilian Railways— Santiago-Valparaiso	2-6-0 + 0-6-2	Passenger	58 6	127	—	—	—	3,000 d.-c.	—	—	6	2,250	—	—	Max. 62·5
Chile, Bethlehem Chile Iron Company	0-4-4-0	Freight	40 6	102	102	35 8	52	2,400	—	—	4	1,370	Twin geared	42,000	12·2

TABLE II.—RECENT ELECTRIC LOCOMOTIVES: EUROPE.

Name of Railway.	Class.*	Type.	Length.	Total Weight. (Tons.)	Weight on Drivers (Tons.)	Total Wheel Base.	Diam. of Driving Wheels.	Distribution Voltage.	Frequency.	Type of Motor.	Number of Motors.	Rated H.P.	Transmission System.	Tractive Effort (Lb.).	Speed, M.P.H.
			ft. in.			ft. in.	in.								
Austrian State Railways ..	1C + C1	—	66 0	127·5	—	—	53·0	15,000 1-phase	16⅔	—	—	2,460	Coupling rods	—	40·0
France, Midi Railway	2 driving bogies	—	—	72·0	—	—	—	—	—	—	—	1,400	—	23,600	56·6
German State Railways ..	—	—	42 0	68·0 metric tons	—	9 6 per bogie	63·0	12,000–16,000	15	—	2	600 per motor	—	29,683	37·0
Great Britain— Metropolitan Railway ..	0-4-4-0 Double bogie all axles driven	—	39 6	56·0	—	29 6	43·5	600	—	—	4	300 each	—	—	Max. 60 Average, 30
North Eastern Railway: (Freight)	—	Articulated truck	39 4	74·0	—	27 0	48·0	1,500 d.-c.	—	—	4	1,100	—	28,000	25·0
(Passenger)	4-6-4	Articulated	—	105·0	—	—	—	1,500 d.-c.	—	—	—	2,500	—	—	Max. 90
Italian State Railways (Baltic type)	3 coupled and 4 trailing axles	—	—	92·0	49·5	—	60·24	3,000–3,700 3-phase	—	—	2	—	Inclined cranks and countershaft	—	Synchronous 62·5 34·75 and 23·25
Italy, Valtellina Railway	1C1	—	36 0	73·0	45–51	—	60·24	3,000 3-phase	—	—	—	—	Triangular frame, connecting rods and jack axles	26,432	25·25
	2C2		43 6	92·0	49·5										31·0 46·5 62·0
Silesian Mountain Railways ..	2D1	—	—	108·0	—	—	—	15,000 1-phase	16⅔	—	1	3,000 1,500	Coupling rods	65,100	35·0 56·0
Sweden, Riksgransen: (Passenger)	B + B + B	—	—	88·5	—	—	62·0	16,000 1-phase	—	—	2	—	—	62,600	62·0
(Goods)	1C + C1	—	—	136·0	—	—	43·25	16,000 1-phase	—	—	1	850	—	—	37·2
Swedish State Railways (Gellivare-Narvik)	—	—	44 3½	68·0	—	27 4½	53·0	12–16,000 1-phase	15	—	—	—	—	40,320	37·0
Swiss Federal Railways (St. Gothard)	1C + C1	—	63 7	141·0	—	—	—	15,000 1-phase	15	—	—	2,200	—	52,900	21·7
Swiss Federal Railways	1B + B1	—	—	108·0	78·2	—	60·24	15,000 1-phase	—	—	2	600	—	—	31·0
Swiss Federal Railways ..	1C C1	—	63 0	128·0	108·0	54 0	60·0	15,000 1-phase	16⅔	1-phase series compensated	4	2,250	Gearing and coupling rods	37,400	40·4
Switzerland, Berne-Loetschberg-Simplon	1B B1	—	43 0	70·0	50·0	34 7	59·0	15,000	16⅔	,,	2	1,000	,,	—	21·75
Switzerland, Rhaetian Railways	C + C	—	45 0	66·0	66·0	34 6	44·0	11,000 1-phase	16⅔	,,	2	1,200	,,	23,100	28·0
Switzerland, St. Gothard..	1B B1	Passenger	54 0	106·0	76·0	—	60·0	15,000	16⅔	—	—	1,800	—	23,000	47·0
	1C C1	Freight	63 0	128·0	103·0	—	53·0	—	—	—	—	2,250	—	37,500	40·0

* Continental class nomenclature, except Great Britain. See explanation at foot of Table III, page 574.

interchangeability which has such a material effect on the economy of upkeep. The chief mechanical adviser of each group will have it in his power to effect economies in maintenance which could never have been brought about while the number of railways was so numerous. The Act of 1921 arranges that in three out of the four groups more than thirty railways are in each case merged into one. Progress in design will still be stimulated by the existence of four organisations, the mechanical engineering requirements of which will bring forward the best brains for directing the general policy of improvement.

With regard to wagon stock, the same influences will be brought to bear, and, fortunately there is already, even before grouping has become effective, a marked tendency to have all wagon details constructed to standard patterns. In my presidential address, November 1918, I dealt with the advantages of the standardisation of wagons, and pointed out what a large number of wagons belonged to private owners. The total numbers of the latter were not at that date known exactly, but a census was taken in August, 1918, by the Board of Trade, which showed that the figure was 614,127 of which 564,394 were employed in coal and coke traffic. It is a gratifying fact that since I mentioned this matter there has been a common agreement arrived at by the railway companies who had the full co-operation

SOME POST-WAR PROBLEMS OF TRANSPORT.

TABLE III.—PRE-WAR ELECTRIC LOCOMOTIVES (4 FEET 8½ INCHES GAUGE.)*

Name of Railway.	Class.†	Type.	Length.	Total Weight. (Tons,)	Weight on Drivers. (Tons.)	Total Wheel Base.	Diameter of Driving Wheels.	Distribution Voltage.	Frequency.	Type of Motor.	Number of Motors.	Rated H.P.	Transmission System.	Tractive Effort (Lb.).	Speed, M.P.H.
			ft. in.			ft. in.	in.								
Metropolitan (London)	0-4-4-0 AA + AA†	Bogie	30 0	47·0	47·0	24 6	38·0	600 c.-c.	—	Series	4	200	Single gearing	15,000	19·5
North-Eastern	0-4-4-0 AA + AA	Bogie	35 0	56·0	56·0	27 0	36·0	550 c.-c.	—	Series	4	90	Single gearing	15,400	8·6
Detroit River Tunnel	0-4-4-0 AA + AA	Articulated bogie	39 6	90·0	90·0	27 6	48·0	600–650 c.-c.	—	Series	4	300	Twin gearing	35,000	12·0
Butte, Anaconda and Pacific ..	0-4-4-0 AA + AA	Articulated bogie	37 4	71·5	71·5	26 0	46·0	2,400 c.-c.	—	Series	4	300	Twin gearing	25,000	15·0
New York Central	4-4-4-4 AA + AA + AA + AA	Double articulated bogie	56 10	112·0	112·0	46 0	36·0	600–650 c.-c.	—	Series	8	330	Direct	20,400	48·0
Pennsylvania	4-4-4-4 2-B + B-2	Articulated	64 11	140·0	89·3	55 11	72·0	650–750 c.-c.	—	Series	2	1,500–2,000	Connecting rod	40,000	(36 at 600 volts normal field)
New York, New Haven and Hartford	2-4-4-2 1-AA + AA-1	Articulated	36 4	91·0	68·9	30 10	62·0	11,000 1-phase	25	Compensated series	4	240	Direct	8,900	40·5
	2-4-4-2 1-AA + AA-1	Articulated	50 0	98·0	75·4	40 6	63·0	11,000 1-phase	25	Compensated series	8	168	Single gearing	18,600	27·5
Lotschberg Simplon	2-10-2 1-E-1	—	48 3	107·0	78·2	37·1	53·2	15,000 1-phase	15	Compensated series	2	1,250	Single gearing and scotch yoke	29,800	31·0
Rhaetian* (Engandine, Switzerland)	2-8-2 1-D-1	—	29 9	48·4	38·7	26·9	42·0	10,000 1-phase	16⅔	Compensated series	2	300	Single gearing and connecting rod	12,670	17·36
Italian State	0-10-0 0-E-0	—	31 3	60·0	60·0	20 0	42·0	3,300 3-phase	16⅔	Polyphase induction	2	1,000	Scotch yoke	30,800	24·3
Italian State	2-6-2 1-C-1	—	36 0	71·0	50–44	27 6	64·1	3,300 3-phase	16⅔	Polyphase induction	2	1,300	Scotch yoke	20,900	46·6
Simplon Tunnel	0-8-0 0-D-0	—	34 0	67·0	67·0	26 2	49·25	3,000 3-phase	16	Polyphase induction	2	550–850	Coupling rod	25,000–13,200	16·15–43·5
Norfolk and Western	2-4-4-2 1-B + B-1 (one unit)	Articulated	52 10 (one unit)	240·0	196·0	42 0 (one unit)	62·0	11,000 1-phase	25	Polyphase induction	8	410	Twin gearing and connecting rod	85,800–46,000	14–28

* Locomotives and rolling-stock on the Rhaetian Railway are built to meter (3 ft. 3⅜ in.) gauge.
† Continental class nomenclature. Initial capitals A, B, C, D, E, denote 1, 2, 3, 4, 5, coupled driving axles. Numerals placed before or after these letters denote the number of pony axles. The plus (+) sign shows the division of driving axles on separate trucks.
NOTE.—The above table has been adapted from one which appeared in A. T. Dover's "Electrical Traction," 1919, page 410.

of the Ministry of Transport as to the standardisation of the 12-ton wagon, which is taking the place of the 10-ton wagon, and now a standard specification has been issued by the Railway Clearing House which says: "Railway companies' and private owners' wagons must be built to this specification." How large an advance this means will be appreciated when it is stated that in course of time this will affect 750,000, both railway and traders wagons, though as time goes on the proportion of railway-owned wagons will increase.

Concentration of workshops will help the railway companies to reduce expenditure, and this applies whether they are concerned with locomotives, carriages, or wagons. The experience in the past has been that where numerous workshops existed on the same railway, the work has not been done with the same economy or the same care in the consumption of stores.

As to the general question of stores, nothing can be worse than that a workshop should be kept waiting for stores, but on the other hand, it requires a nice appreciation on the part of the officer in charge to see that while the demands made upon him for stores can be instantly complied with, the total quantity and value of his stock is kept down to the smallest figure which will maintain continued progress in the workshops.

To the economies the railways themselves can effect, ought to be added relief from some of the burdens which they now bear. In 1921, 24 of the British railways contributed nearly 11,055,408*l.* in the form of rates and taxes, and a large proportion of this was expended in the maintenance of roads, which in many cases the railway companies do not themselves use. In fact, there are many country districts through which railways run but have no stations, and no necessity for road user, where they pay anything from 5 to 90 per cent. to parish rates, and are thus maintaining the roads which are being used more and more by the competitive road motor traffic which escapes all such local charges, while the railways have to pay something in the way of rates on every yard of their own track and pay the cost of its maintenance as well. These serious charges form a great tax on transport. Recently very strong complaints have been made on this head, though such complaints are of a very old order indeed, as we can see when reading that Mr. Glyn, the then chairman of the London and North-Western Railway, stated in February, 1848, when referring to the growing amount of rates and taxes: "It is a crying grievance, and, in point of fact, those of you who live in the country on a line of railway, know that the county and parochial authorities are in the habit of looking to the railway in order to saddle upon the company the greater part of the charges which ought to fall upon the parish."

Seeing that the sums paid by the railway companies towards local road maintenance are so high, they may find, if they carry out large projects of road traction themselves, that their equitable demand for a revision of local taxation will be rendered unreasonable, if they themselves add largely to the wear and tear of roads. A remission of local taxation might turn out in the case of some railways, and in some localities, to be a more profitable thing than any net increase which they might have gained by road haulage. It is not merely a question of the high figures which the railways pay to-day, but the rapid growth of road traction will inevitably lead to much higher charges, as taxation in some form for the maintenance of roads is not likely to grow less if the remarkable figures recently published by Mr. A. E. Brookes, one of our members who is the Engineer to the Durham County Council, are an indication of what may be expected on our great main roads. He shows that on the Great North Road the "tons per yard width of road per day" were, in 1912, 77·7, but grew in 1920 to 300·8 per day, and that out of this 300 tons 51·5 per cent. was due to heavy motors and tractors, which in 1912 only did 16·9 per cent. of the work. This form of goods transport is said to involve at present the use of 300,000 vehicles, and we already expend 50,000,000*l.* a year on road maintenance. The equity of the case appears to demand that those who do the damage should pay the cost of repair in proportion to user, and that some method should be evolved of a dual character whereby measurement of mileage, combined with weight, should be made use of instead of the present horse-power measurement which has worked out so inequitably on those who pay motor taxes.

(To be continued.)

CATALOGUES.

Steel Window Frames.—A catalogue of steel window frames has come from Messrs. Frederick Braby and Co., Limited, Glasgow, showing several forms, fixed or opening, and for putty or sealed glazing.

Instruments.—Leaflet catalogues of a steam flow meter and a steel-mercury pyrometer, each made in a range of sizes, are to hand from Engineering Supplies, Limited, 11, Queen Victoria-street, London, E.C. 4.

Machine Tools.—The Associated British Machine Tool Makers, Limited, 17, Grosvenor Gardens, London, S.W 1, send a copy of the March-April issue of their journal, which contains some interesting technical matter about machine tools and their operation.

Portable Brick-Making Machines. — Machines for making concrete bricks, roofing tiles, partition slabs, building blocks and mixing colour with concrete are described in a special catalogue received from Messrs. Vickers, Limited, Broadway House, Westminster, London, S.W. 1.

Electric Heating.—Messrs. George Nobbs, Limited, 89, Cleveland-street, London, W. 1, send a copy of a catalogue illustrating and explaining their system of electric radiation for land and ship installations. The radiators are made in units which permit of adaptation to any size of room.

Electric Motors.—A special catalogue of multi-speed induction motors containing several pages of matter explaining the construction, operation and range of application of these machines, comes from the Electric Construction Company, Limited, Wolverhampton. The motors are made under the Creedy patents.

Electrical Apparatus.—A number of leaf catalogues received from Messrs. Watts, Fincham and Co., Limited, 22, Billiter-street, London, E.C. 3, describe ordinary and safety hand lamps; a lamp for examining the inside of casks, boxes, cisterns and other enclosed places; steel alkaline accumulators; and an insulator for conductor rails.

Gas Engines.—One of the great merits of the gas engine is that it can be used as an economical means of producing power from gases, such as those from coke ovens and blast furnaces, which were formerly waste products. A catalogue received from the National Gas Engine Company, Limited, Ashton-under-Lyne, reprints a large number of letters from colliery and other companies testifying to the satisfactory results obtained from large power vertical tandem gas engines supplied by the National Company, and capable of running on such gases or on producer or town gas.

Malleable Castings.—Some useful data on malleable castings are given in a booklet received from the Incandescent Heat Company, Limited, who produce these castings on an extensive scale at their British Mills Foundry, Smethwick, Birmingham. The mixture of metal, the method of casting and the annealing process are all described, and a table is given of the results obtained by tensile, bending, and impact, tests with the corresponding results for iron and steel castings, and drop stampings. Some illustrations of fairly complex castings are included in the booklet.

ERRATUM.—We regret to find that, by a printer's error, the catalogue of exhausters referred to on page 475 *ante* was stated to have been received from Messrs. George Walter and Son, Limited, whereas the correct name and address of the firm issuing it are Messrs. George Waller and Son, Limited, Phœnix Iron Works, Stroud, Gloucestershire.